Effective Standardization Management in Corporate Settings

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Chapter 7
An Innovative Approach to the Development of Project Management Processes for Small-Scale Projects in a Large Engineering Company

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ABSTRACT

A 400-employee Canadian division of a large American engineering company has developed and implemented project management processes for their small-scale and medium-scale projects. The company was already using a robust project management process for their large-scale projects. The objectives of this project were to reduce cost overruns and project delays, standardize practices to facilitate the integration of new managers, increase the level of customer satisfaction and to reduce risk-related planning deviations. For this project, the engineering organization used the ISO/IEC 29110 standards developed specifically for very small entities, i.e. organizations, having up to 25 people. An analysis of the cost and the benefits of the implementation of small and medium scale project management processes was performed using the ISO economic benefits of standard methodology. The engineering enterprise estimated that, over a three-year timeframe, savings of about 780,000$ would be realized due to the implementation of project management processes using the ISO/IEC 29110 standard.

INTRODUCTION

Standards are sources of codified knowledge and studies have demonstrated the benefits of standards, such as product interoperability, increased productivity, market share gains, and improved interaction with stakeholders such as enterprises, government organizations and the public. Standards and associated

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technical documents could be considered as a form of technology transfer and, if the right standards are selected and used correctly they should have an economical impact in an organization.

Many advantages or benefits as well as disadvantages or costs have been reported regarding the use of voluntary standards. Table 1 lists a few of the advantages and disadvantages reported.

The most recent study on the economic benefits of standardization (Miotti, 2009), performed by the French standardization organization AFNOR, showed that standardization made a significant contribution to growth of the French economy during the 1950-2007 period, i.e. 0.81% per year or almost 25% of GDP growth. The study was based on a survey of 1,790 French companies or organizations of all sizes and from all sectors of activity where 30% of respondents were from enterprises of less tan 20 employees, 47% from small and medium enterprises (i.e. 250 employees or less) and 23% from large companies (i.e. more than 250 employees). The contribution of standards to the French economy is in line with data illustrated in Table 2 for other countries, such as Germany and Australia. In addition to known benefits of standards, five major lessons emerge from the French study (Miotti, 2009):

- Company value enhancement: The knowledge capital contributed by corporate involvement in standardization work represents true value.
- Innovation: Standardization promotes the dissemination of innovation. It emphasizes a product's advantages and constitutes a product selection tool.
- Transparency and ethics: Standards contribute to better compliance with the rules of competition. By establishing the rules of the game, standards make it easier to eliminate players who fail to comply.
- International: By promoting the development of international exchanges, standardization provides companies with a genuine passport for exporting their products.
- Product and service quality: Standardization gives companies a great degree of control over safety-related problems and provides a genuine guarantee of quality.

Table 1. Advantages and disadvantages of voluntary standards reported (adapted from Miotti, 2009; Land, 1997)

Advantages or Benefits	Disadvantages or Costs
• Promote innovation • Improve efficiency of an organization • Increase competitiveness • Facilitate the access to a wider market • Clarify the rules of a market • Improve quality of products and services • Promote improvement of Processes • Facilitate partnerships • Improve the image, credibility of organizations • Promote a uniform terminology • Regularly updated • Facilitate the selection of suppliers and partners • Facilitate access to recognize knowledge • Facilitate access to investments and financing	• Difficult to understand • Cost of acquire standards • Cost of standard implementation • Cost of certification • Require outside expertise to implement them • Conflicting standards • High number of standards available • Describe only 'what to be done' not 'how to do it' • Insufficient guidance to select and apply them • Slow evolution of standard may impede innovation • Difficult and costly to apply in small organizations • Difficult to demonstrate 'savings' • Many producers of standards • Perception that standards add unnecessary bureaucracy to an organization

Table 2. Comparative contribution of standards to national economies (adapted from Miotti, 2009)

	Germany (DIN)	UK (DTI)	Standards Council of Canada	Australia Standards	France (AFNOR)
Period subject to analysis	1961-1990	1948-2001	1981-2004	1962-2004	1950-2007
Growth rate of GDP (%)	3.3	2.5	2.7	3.6	3.4
Contribution to growth of GDP (%)	27.3	11.0	9.0	21.8	23.8
Impact in % points on GDP growth	0.9	0.3	0.2	0.8	0.8

Any organization, especially a large organization, can benefit from the lessons described above by using consensus-based standards in the products, services or research activities they conduct. Smaller organizations can also benefits from the use of standards. Also, even large organizations, such as multinational enterprises or government agencies, have a wide range of project size to manage. Their multimillion dollar projects may involve hundreds of people while their smallest projects may involve many teams of 5 to 10 people.

Unfortunately, many standards, such as systems engineering and software engineering standards, have been developed by large organizations without having in mind smaller settings. Most small organizations do not have the expertise or the resources to participate to standard development. A large majority of enterprises worldwide are very small entities (VSEs). In Europe, for instance over 92% of enterprises, called micro-enterprises, have up to 9 employees and another 6.5% have between 10 and 49 employees (Moll, 2013).

In 2004, an ISO working group (ISO/IEC JTC1 SC7[1] Working Group 24) was mandated to develop a set of standards and guides to address the issues facing VSEs (Laporte et al., 2013a; Laporte & O'Connor, 2014a). Members of the working group had developed a list of hypotheses about VSEs (adapted from Laporte et al., 2008a):

- The VSE context requires light and well-focused life-cycle standards and guides.
- Particular business contexts require particular standards and guides.
- There are significant differences in terms of available resources and infrastructure between an enterprise employing up to 10 people and an IT department of the same size in a larger organization.
- VSEs are limited in both time and resources, which leads to a lack of understanding about how they can use standards for their benefit. VSEs need guidelines to help them apply standards.
- Benefits for VSEs might include recognition through an assessment or an audit by an accredited body.

A survey performed by the ISO working group showed that VSEs found it difficult to relate ISO standards to their business needs and to justify the application of the standards to their business practices. Also, the survey indicated that most of the VSEs were not able to afford the resources—in number of employees, cost, and time—or see a net benefit in establishing Processes (Laporte et al., 2008a). The results of the survey as well as the experience of the members of the working group have guided the development of a four-stage roadmap providing a progressive approach to satisfying the needs and expectations of a vast majority of VSEs. This roadmap has been published as a set of ISO/IEC 29110 standards and technical reports.

We describe in this chapter the main activities associated with the development and implementation of project management Processes for small and medium scale engineering projects in a Canadian division of an American engineering company (Chevalier, 2012). Even though this organization is considered a large enterprise, a large number of their projects are within the scope of the new ISO/IEC 29110 developed specifically for VSEs (i.e. enterprises, organizations, departments and projects having up to 25 people). We present the business objectives of the improvement project, the approach to select the frameworks used to document the Processes, a brief description of the ISO/IEC 29110 standards used to document the project management Processes, the methodology used to estimate the cost and benefits of the Process documentation activities and a description of the Processes and their support tools.

MAIN FOCUS OF THE CHAPTER

The project management Process improvement program was targeted at one Canadian division of a large American engineering company, which was created a decade ago and now boasts around 400 employees across 10 offices throughout Canada. This division, as a relatively new entity, has established a Quality Management System (QMS) and has been certified against ISO 90001:2008 standard. The division had no efficient tools or project management Processes suited to managing small-scale projects. The strong growth of the division in recent years made management aware of the need to improve its methods in order to remain competitive. For this reason, most of the projects managed by this division include project plans and cost-time estimates. In most cases, these projects involve updating or improving existing electric power infrastructures. Hence the challenge of handling multiple small-scale, fast-moving projects allowing little room for unwieldy management Processes, but still requiring an efficient and straightforward monitoring Process.

The improvement program's objective was to avoid cost overruns and project delays, to standardize practices to facilitate the integration of new managers, to increase the level of customer satisfaction and to reduce risk-related planning deviations.

MANAGING PROJECTS OF VARYING SCALE

Projects in one division, of the engineering enterprise, were classified into three categories according to duration, size, number of disciplines involved and engineering fees. It was decided to classify the engineering projects into three categories: small-, medium- and large-scale projects. As illustrated in Table 3, over 95% of the projects fall in the small- and medium-scale categories.

The goal-problem approach, developed by Potter and Sakry (2002), was used to set the improvement program's priorities and to ensure that the goals set by the program addressed tangible problems that the company wished to solve. This approach includes the following steps:

- Determine the business goals (see Table 4) and the problems that the company wishes to solve
- Group goals and problems
- Prioritize problems
- Develop and implement an action plan

Table 3. Classification of the division's projects (in Canadian Dollar)

	Small Project	Medium Project	Large Project
Duration of project	Less than 2 months	Between 2 and 8 months	More than 8 months
Size of team	Up to 4 people	Between 4 and 8 people	More than 8 people
Number of engineering specialties involved	One	More than one	Many
Engineering fees	Between $5,000 and $70,000	Between $50,000 and $350,000	Over $350,000
Percentage of projects	70%	25%	5%

Table 4. Division's business goals

Objective ID	Description
O-1	Facilitate the integration of new project managers.
O-2	Achieve a global customer satisfaction level of 80%.
O-3	Meet the deadlines and costs planned for the projects, within a margin of 5%.
O-4	Reduce resource overload by 10%.
O-5	Reduce time delays to one week and cost overruns to 5% of the initial budget.
O-6	Reduce corrective work during the quality control phase by 10%.
O-7	Reduce non-chargeable time for resources by 10%.

Table 5 presents a list of 16 problems, ranging from estimation problems to lack of defined project management practices and tools, that slow down the achievement of the 7 business objectives listed in Table 4.

Managers of the engineering division grouped the problems relative to the 7 goals. Finally, they estimated the expected cost and benefit of each objective in order to prioritize them and group them in different implementation phases. Table 6 shows the estimated cost, benefits and the prioritization of the business objectives.

To verify the achievement of the objectives, a set of questions and indicators have been defined. Table 7 shows the set of questions and indicators used to assess the progress of the improvement program against established objectives.

Since not all objectives could be addressed at the same time, it was decided to address objectives 1, 2, 3 and 5. Table 8 shows an example of an objective and a task to achieve it.

As the last activity of this objective setting phase, a risk management plan was developed in order to prevent – i.e., reduce the probability and minimize the impact of – certain events on the project Process.

SELECTION AND EVALUATION OF IMPROVEMENT FRAMEWORKS

There are several frameworks which describe recognized project management practices, such as the Guide to the Project Management Body of Knowledge (PMBOK® Guide) published by the Project Management Institute (PMI, 2013); maturity models such as the Capability Maturity Model Integration (CMMI®) for

Table 5. Problems that slow down the achievement of business objectives

Problem ID	Description
P-1	Difficulty in integrating new project managers
P-2	Lack of knowledge of existing tools
P-3	Difficulty faced by new project managers to understand the ways of doing business of the division
P-4	Projects in difficulty due to poor time management
P-5	Projects in difficulty due to poor management of resources
P-6	Project implementation cost overruns
P-7	Difficulty in managing change requests
P-8	Difficulty in communicating change requests
P-9	Difficulty in estimating workload and resources
P-10	Difficulty in monitoring project progress due to a lack of project standardized project management practices
P-11	Incorrect estimation of resources to successfully carry out projects
P-12	Lack of experience or knowledge of some project managers
P-13	Lack of defined Processes and appropriate tools
P-14	Customers dissatisfied with schedule slippage
P-15	Lack of risk monitoring
P-16	Slippage of project schedules

Table 6. Prioritization of the objectives (from 1 (low) to 10 (high))

Objective Identification	Objective Description	Estimated Benefits [1-10]	Estimated Cost [1-10]	Priority (Benefits/Cost)
O-1	Facilitate the integration of new project managers.	5	10	0.50
O-2	Achieve a global customer satisfaction level of 80%.	7	4	1.75
O-3	Meet the deadlines and costs planned for the projects, within a margin of 5%.	10	10	1.0
O-4	Reduce resource overload by 10%.	6	6	1.0
O-5	Reduce time delays to one week and cost overruns to 5% of the initial budget.	10	7	1.43
O-6	Reduce corrective work during the quality control phase by 10%.	8	8	1.0
O-7	Reduce non-chargeable time for resources by 10%.	5	8	.63

Development of the Software Engineering Institute (SEI, 2010); and standards such as the new ISO/IEC 29110 series for VSEs (ISO, 2011b). Table 9 presents a few well-known project management frameworks.

A meeting with the improvement program sponsors helped define a set of criteria to determine the most suitable project management framework for the engineering division. The following criteria were selected:

Table 7. Questions and indicators to assess the achievement of objectives

Objective ID	Questions and Indicators
O-1	- Do the new project managers follow the project management Process? - Do they complete the required forms of the Process? - Are they able to classify project documents at the right place on the repository?
O-2	- What is the level of customer satisfaction about the management of his project?
O-3	- Does the project manager meet the deliverable dates as agreed with the customer? - Does the project meet its budget?
O-4	- Do the project resources have to work overtime?
O-5	- Has the project manager performed a risk analysis? - Has the project manager performed risk management? - Has the project manager addressed the risks?
O-6	- Does the quality control team have to rework engineering products when verifying deliverables?
O-7	- What is the amount allocated for non-billable resources to a customer?

Table 8. Example of intermediate objectives for one business objective

Objective ID	Main Objective/ Intermediate objective	Goal of an Objective	Task
Business Objective O-1	**Facilitate the integration of new project managers.**	Reduce the cost of integrating new employees Raise the skill level (or effectiveness) of managers.	
	Define and standardize project management practices.		Develop Processes and tools to support project execution.

- The framework is suitable for the management of small-scale projects (small team and limited means),
- The company's management knows the framework,
- The framework is recognized by the company's customers,
- Tools are available to facilitate the use of the framework,
- The framework may easily be used and integrated into the existing Processes,
- A recognition mechanism through accreditation for the company is available,
- The framework is readily available.

Before analyzing the selected frameworks, each criterion was weighted by its importance according to the project sponsors. Table 10 describes the 7 criterion used to evaluate the frameworks as well as the justification for the weight assigned to each criterion.

The sponsors evaluated the 5 frameworks using the weighted selection criteria. Figure 1 illustrates the evaluation of the frameworks selected. The final score for each framework is obtained by multiplying each individual score by the weight of each criterion and then adding the individual scores. As illustrated in Figure 1, the PMBOK® Guide and the ISO/IEC 29110 standard obtained the highest overall score.

Table 9. Well-known project management frameworks[2]

Guide to Project Management Body of Knowledge (PMBOK® Guide)	Developed by the Project Management Institute, it provides project managers with the fundamental practices needed to achieve organizational results and excellence in the practice of project management (PMI, 2013a).
Organizational Project Management Maturity Model (OPM3®)	Developed by the Project Management Institute, it provides the tools organizations need to measure their maturity against a comprehensive set of organizational best practices (PMI, 2013b).
PRINCE2®	A structured project management method based on experience drawn from thousands of projects and from the contributions of countless project sponsors, Project Managers, project teams, academics, trainers and consultants (AXELOS, 2009).
Capability Maturity Model® Integration (CMMI®)	Developed originally by the Software Engineering Institute and now under the management of the CMMI Institute, the set of CMMI models are collections of best practices that help organizations to improve their Processes (SEI, 2010).
ISO/IEC/IEEE 16326 - Systems and software engineering — Lifecycle Processes — Project management	This standard provides normative content specifications for project management plans covering software projects, and software-intensive system projects. This International Standard also provides detailed discussion and advice on applying a set of project Processes that are common to both the software and system life cycle as covered by ISO/IEC/IEEE 12207:2008, Systems and software engineering – Software life cycle Processes, and ISO/IEC/IEEE 15288:2008, Systems and software engineering – System life cycle Processes, respectively. The discussion and advice are intended to aid in the preparation of the normative content of project management plans (ISO, 2009).
ISO/IEC/IEEE 16085 - Systems and software engineering — Lifecycle Processes — Risk management	This standard defines a Process for the management of risk in the life cycle. It can be added to the existing set of system and software life cycle Processes defined by ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207, or it can be used independently. ISO/IEC/IEEE 16085 can be applied equally to systems and software (ISO, 2006).
ISO/IEC/IEEE 12207 – Software lifecycle Processes	This standard establishes a common framework for software life cycle Processes, with well-defined terminology, that can be referenced by the software industry. It contains Processes, activities, and tasks that are to be applied during the acquisition of a software product or service and during the supply, development, operation, maintenance and disposal of software products. Software includes the software portion of firmware (ISO, 2008a).
ISO/IEC/IEEE 15288 – System lifecycle Processes	This standard establishes a common framework for describing the life cycle of systems created by humans. It defines a set of Processes and associated terminology. These Processes can be applied at any level in the hierarchy of a system's structure. Selected sets of these Processes can be applied throughout the life cycle for managing and performing the stages of a system's life cycle. This is accomplished through the involvement of all interested parties, with the ultimate goal of achieving customer satisfaction (ISO, 2008b).

Table 11 describes the frameworks evaluated, the cumulative score of each framework evaluated as well as the justifications for each score and the decisions (e.g. select, discard) about each framework.

The ISO/IEC 29110 was the framework selected for the improvement project. Even if the company's division comprises more than 400 employees a significant number of small- and medium-scale projects are carried out by small teams. Since the ISO/IEC 29110 standard applies to Very Small Entities (VSEs), i.e. enterprises, organizations, departments and projects having of up to 25 people, this standard was very suitable for the engineering division of the company.

OVERVIEW OF ISO/IEC 29110 STANDARDS AND TECHNICAL REPORTS

This section describes the approach used by WG24 to develop a set of standards and technical reports to address the needs of VSEs. This section also describes the management and engineering guide used by the engineering division to develop their small-scale and medium-scale project management Processes.

Table 10. Weights of the criteria used to evaluate the five frameworks

Description of the criteria	Weight assigned to each criterion (1 = Low importance to 3 = High importance)	Justification
Adapted for the management of small projects	3	- The majority of projects are small projects. - A complex method will need to be adapted to small and medium scale projects to be effective. - Using standards already adapted to small projects could reduce the effort required for the development of small and medium scale project Processes.
Known to the management of the organization	2	- Using a known framework could promote the commitment of management to solutions that will be developed.
Recognized by the company's customers	2	- Some customers have project management practices based on standards. - The use of similar frameworks could facilitate communication and the monitoring of projects with customers.
Tools to facilitate the use of standards are available	2	- Using standards supported with tools could reduce the effort for the development of Processes.
Ease of integration with existing organizational Processes	3	- It is very important that the standards can be used in the current business context. - Existing Processes are not under the responsibility of the Division and therefore cannot be changed easily. - Changes made in the Division should not force changing the practices employed by other divisions.
Accreditation/ Certification available	1	- The company does not currently show interest for accreditation related to project management practices.
Ease of access to frameworks	1	- The company has the monetary means to acquire the frameworks. - The impact of this criterion is small.

There is a wide spectrum of development approaches for organizations developing software. Figure 2 illustrates the spectrum of approaches. On the vertical axes are illustrated the approaches based on the level of risk. The upper part of the vertical axis illustrates a low risk linear approach using a waterfall approach while the lower part of the axis illustrates a risk-driven project using an iterative approach. On the horizontal axis, the level of ceremony varies from a low ceremony approach with little or no documentation (e.g. agile approach) to a high ceremony approach with a comprehensive documentation and the use of standards (e.g. ISO/IEC/IEEE 16085 risk management standard) and frameworks (e.g. CMMI®). As we will illustrate in the next paragraphs, the new standard developed specifically to address the needs of very small entities, i.e. the family of ISO/IEC 29110 International Standards (ISs) and Technical Reports (TRs), is located at about the centre of both axes. VSEs will be able to use ISO/IEC 29110 in a wide spectrum of approaches.

Many international standards have been developed to capture such proven management and engineering practices. However, these standards were not written for very small organizations and were consequently difficult to apply in such settings. An ISO Working Group (Working Group 24, WG24) has been established to address these difficulties (ISO, 2005).

WG24 used the 6-stage model of the innovation-development Process model, developed by Rogers (2003) to develop the set of ISs and TRs. Rogers defines the innovation-development Process as follows:

Figure 1. Scores of the five frameworks selected

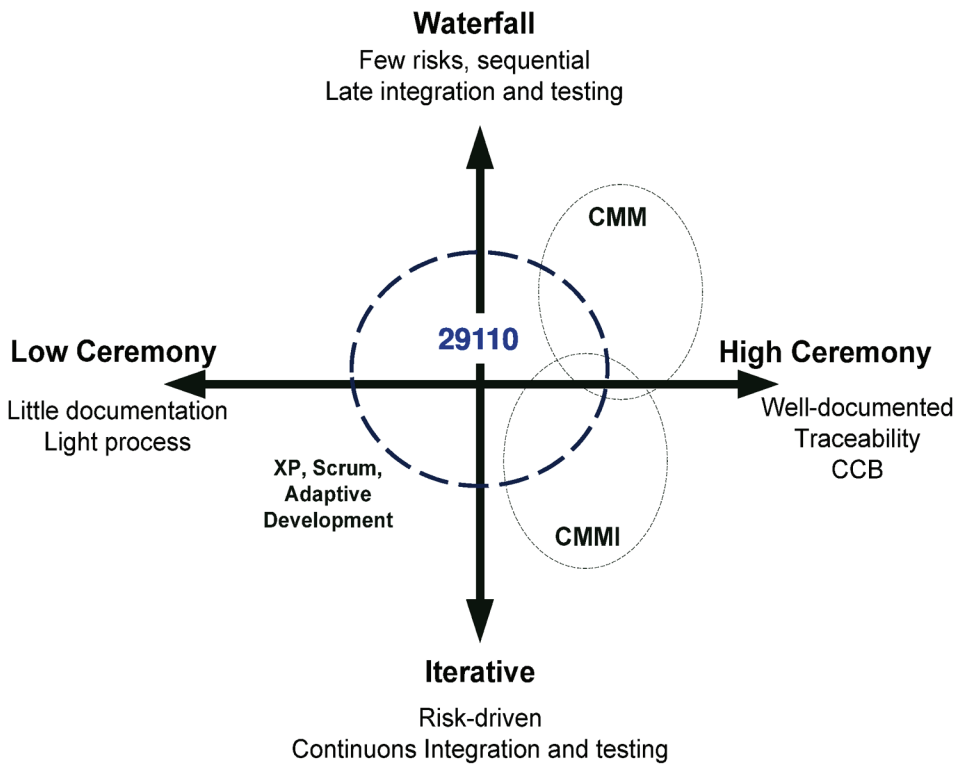
	Evaluation criteria							
	Adapted for the management of small projects		Known to the management of the organization		Recognized by the company's customers		Tools to facilitate the use of standards are available	
Framework	Weight assigned to each criteria	Evaluation of framework using criteria	Weight assigned to each criteria	Evaluation of framework using criteria	Weight assigned to each criteria	Evaluation of framework using criteria	Weight assigned to each criteria	Evaluation of framework using criteria
CMMI-DEV, version 1.3	3	1	2	1	2	0	2	2
CMMI-SVC, version 1.3	3	1	2	0	2	0	2	2
PMBOK Guide (PMI)	3	1	2	3	2	3	2	2
PRINCE2 2009 Edition	3	1	2	0	2	0	2	2
ISO/IEC 29110	3	3	2	0	2	0	2	3

	Evaluation criteria						
	Ease of integration with existing organizational processes		Accreditation/Certification available		Ease of access to documents		
Framework	Weight assigned to each criteria	Evaluation of framework using criteria	Weight assigned to each criteria	Evaluation of framework using criteria	Weight assigned to each criteria	Evaluation of framework using criteria	Total Score
CMMI-DEV, version 1.3	3	1	1	3	1	3	**18**
CMMI-SVC, version 1.3	3	1	1	3	1	3	**16**
PMBOK Guide (PMI)	3	3	1	0	1	3	**31**
PRINCE2 2009 Edition	3	1	1	2	1	1	**13**
ISO/IEC 29110	3	3	1	2	1	3	**29**

Table 11. Analysis and justification of the five frameworks

Frameworks Evaluated	Cumulative Result	Decision about a framework	Justification
CMMI® for Development, V1.3	18	Not selected	- This document is not well known by the management of the company and its customers. - Sponsors of the improvement project showed little interest in this document.
CMMI® for Services, V1.3	16	Not selected	- This document is not well known by the management of the company and its customers. - Sponsors of the improvement project showed little interest in this document.
PMBOK® Guide 4th edition	31	Selected for the large-scale projects	- It is a known document of the management of the company and its customers. - Sponsors of the improvement project have expressed interest in this document. - This framework is not specifically designed for small projects. It will be used only to complete the documentation for the large-scale projects Process.
PRINCE2®, 2009 edition	13	Not selected	- It is a repository little used in Canada. - Sponsors of the improvement project have little interest in this repository.
ISO/IEC 29110	29	Selected for documenting the Process of small projects and medium-scale projects	- It is an unknown repository from management of the company and its customers. - This framework is specially designed for small projects. - However, the concepts of project management of this repository are in line with those described in the PMBOK Guide. - This framework will be used for the development of project management Processes for small and medium scale projects.

Figure 2. Positioning of the ISO/IEC 29110 (adapted from Kroll and Kruchten 2003)



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.

We briefly outline the stages of Rogers model and the actions done by WG24 to design and develop the new standard (Laporte, 2009):

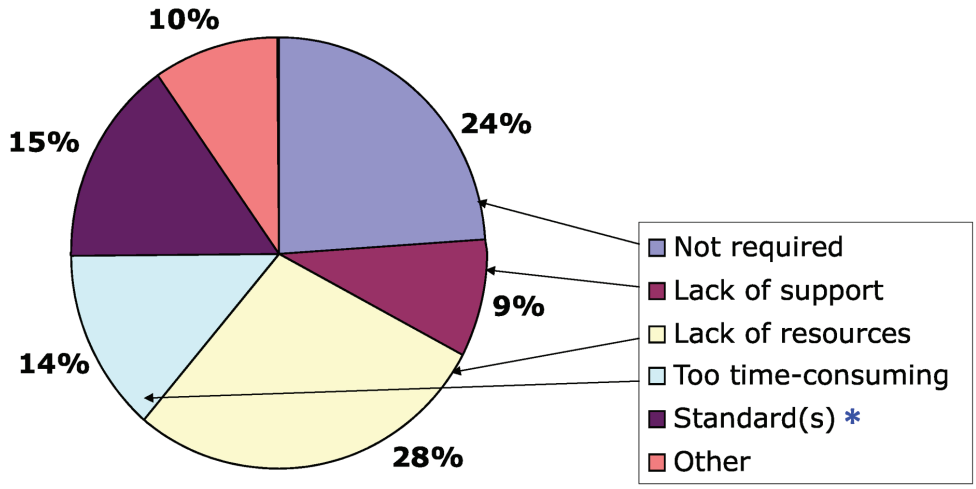
- *Stage 1 The Recognition of Needs and Problems:* Is primarily concerned with the awareness of a problem. In this stage, WG24 documented the lack of awareness and acceptance of existing standards by small and very small software companies and justified the need for a new approach to the development of Process standards aimed specifically at very small companies.
- In *Stage 2 Basic and Applied Research:* WG24 designed and conducted an international survey of very small software companies (described below), leading to an enhanced understanding of the needs of very small software companies from a Process standard.
- In *Stage 3 Development:* WG24 used an innovative approach for the development of the new standard as well as a novel approach to support the implementation, i.e. the development of a set of Deployment Packages.
- In *Stage 4 Commercialization:* ISO is the organization that is publishing and selling ISs and TRs. ISO/IEC 29110 ISs and TRs and made them available on its web site. WG24 obtained from ISO that the set of TRs would be made available at no cost on the ISO web site.

- In *Stage 5 Diffusion and Adoption:* WG24 developed a set of activities to accelerate the dissemination aimed at those VSEs wishing to put in place a minimal set of software development and management practices. As an example, a series of mini-research pilot projects with very small software companies were conducted as a means to accelerate the adoption and utilization of ISO/IEC 29110.
- In *Stage 6 Consequences of an Innovation:* A list to present the potential negative consequences of the publication of standards was developed (Laporte, 2009) and the evaluation of the benefits of ISO/IEC 29110 were estimated using the ISO methodology presented in this chapter. For VSEs, the ISO methodology is too demanding. Two examples of the benefits, using the cost of software quality classification developed by Krasner (1998) have been published recently (Garcia et al., 2015; Laporte et al., 2014c). In these two examples, the cost of rework *(that is, wasted effort)* for projects of about 900 hours was between 13% and 18% of the total project effort. Organisation with a high level of maturity, i.e. having a defined organizational Process, typically have about 15% to 25% of rework (Krasner, 1998).

At stage 2, WG24 conducted a survey, in 9 languages (English, French, German, Korean, Portuguese, Thai, Turkish, Russian and Spanish), of small and very small organizations to question them about their use of standards as well as to collect data to identify problems and potential solutions to help them apply standards. The survey was 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 32 countries. The main findings were documented in (Laporte et al., 2008c), however some salient points are discussed here.

WG24 anticipated the weak use of standards by VSEs by asking questions designed to provide a better understanding of the reasons for this. There are three main ones, as shown in Figure 3. The first

Figure 3. Why don't VSEs use standards? (Laporte et al., 2008a)



* Difficult, Bureaucratic, not enough guidance.

is a lack of resources (28%); the second is that standards are not required (24%); and the third derives from the nature of the standards themselves: 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.

Over 62% of the responses, received from 32 countries, indicated they would like more guidance with examples, and 55% were asking for lightweight and easy-to-understand standards, complete with templates. Finally, the respondents indicated that it had to be possible to implement standards with minimum cost, time, and resources (Laporte et al., 2008a).

The main objective of the new ISO/IEC 29110 standard is to assist and encourage VSEs to improve their systems engineering and/or software engineering Processes. The approach used by the ISO working group mandated to develop ISO/IEC 29110 standards and guides was to develop a 4–stage roadmap by selecting a minimal set of Process elements and documentation elements from existing international standards such as the software life cycle standard ISO/IEC/IEEE 12207 (ISO, 2008a), the systems engineering life cycle standard ISO/IEC/IEEE 15288 (ISO, 2008b) and the documentation standard ISO/IEC/IEEE 15289 (ISO, 2011a).

The ISO working group decided to develop a set of 4 profiles, i.e. a four-stage roadmap (Entry, Basic, Intermediate, Advanced) providing a progressive approach to satisfying the needs and expectations of a vast majority of VSEs. The first set of profiles, as illustrated in Table 12, called Generic profiles, is targeted at VSEs not involved in the development of critical systems or critical software. VSEs targeted by the Entry Profile are VSEs working on small projects (e.g. at most six person-months effort) and for start-up VSEs. The Basic Profile describes development practices of a single application by a single project team of a VSE. The Intermediate Profile is targeted at VSEs developing multiple projects within the organizational context taking advantage of it. The Advanced Profile is targeted to VSEs that want to sustain and grow as an independent competitive development business.

The set of ISO/IEC 29110 documents has been developed to address the needs of various audiences. As an example, the Management and engineering guide is mainly targeted at VSEs and their customers. At the request of WG24, all ISO/IEC 29110 technical reports (i.e. Part 1, 3 and 5) are available at no cost from the ISO web site. The management and Engineering Guides, the most valuable documents for VSEs, are available in English, French, Japanese, Portuguese and Spanish.

For illustration purposes, we will briefly describe one profile used by the engineering division, i.e. the Basic profile, to develop the medium-scale project management Process of the engineering organization. At the time that the project management improvement program was launched, only the software engineering Entry and Basic profiles had been published by ISO. The ISO/IEC 29110 systems engineering profiles were published after this improvement project had been completed. Even though, as illustrated

Table 12. 4-Stage ISO/IEC 29110 Roadmap (O'Connor et al., 2010)

Entry	Basic	Intermediate	Advanced

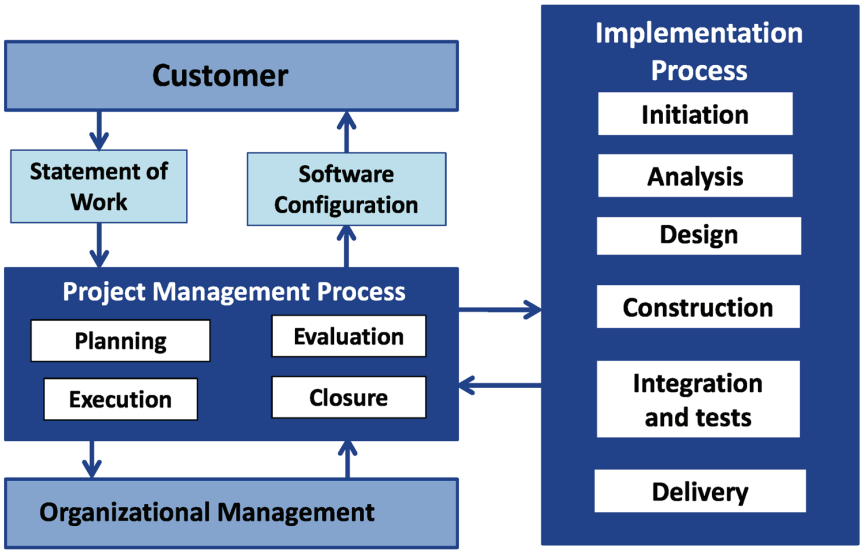
in Figure 4, the Entry and Basic profiles are composed of a project management (PM) Process and a software implementation (SI) Process, only the project management Processes were used to develop the small-scale and medium-scale project management Processes of the engineering organization.

As illustrated in Figure 4, the customer's Statement of Work (SOW) is used to initiate the PM Process. The project plan will be used to guide the development of the software. The PM Process closure activity will deliver a Software Configuration (i.e. product and documentation) and will obtain the customer's acceptance to formalize the end of the project.

The purpose of the PM Process is to establish and carry out in a systematic way the tasks of the project in order to meet the objectives in the expected quality, time and costs. The seven objectives of PM Process of the Basic profile are (ISO, 2011b):

- PM.01 - 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.02 - Progress of the project is monitored against the *Project Plan* and recorded in the *Progress Status Record.* Corrections to remediate problems and deviations from the plan are taken when project targets are not achieved. Closure of the project is performed to get the Customer acceptance documented in the *Acceptance Record*.
- PM.03 - The *Change Requests* are addressed through their reception and analysis. Changes to software requirements are evaluated for cost, schedule and technical impact.
- PM.04 - Review meetings with the Work Team and the Customer are held. Agreements are registered and tracked.
- PM.05 - *Risks* are identified as they develop and during the conduct of the project.

Figure 4. Processes and activities of the software engineering Basic and Entry profiles (Laporte & O'Connor, 2014b)



- PM.06 – 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. The storage, handling and delivery of the items are controlled.
- PM.07 - Software Quality Assurance is performed to provide assurance that work products and Processes comply with the *Project Plan* and *Requirements Specification*.

During the project planning activity, a project plan is developed. Then, the assessment and control tasks are used to assess the project's progress against the project plan. Action is then taken, if needed, to eliminate deviations from the project plan or to incorporate changes to the plan. The project closure activity groups together the deliverables produced by the implementation Process, such as the software or the user manual, and gets the customer's written acceptance to finalize the project. A repository is established to save the work products and to control their versions during the project.

Figure 5 illustrates the 4 activities of the PM Process as well as their input and output products. Each activity is composed of a set of tasks. The task description doesn't impose any technique or method to perform it. Even though Figure 5 describes the PM Process in a waterfall or sequential approach, ISO/IEC 29110 is not intended to preclude the use of different life cycles such as iterative, incremental, evolutionary or agile.

To show the links between ISO/IEC/IEEE 12207 and the objectives of the PM Process, Figure 6 shows the outcomes of the ISO 12207 project planning Process and measurement Process used to develop Objective PM.01 of the PM Process of ISO/IEC 29110.

Note that only a subset of the ISO/IEC/IEEE 12207 project planning and measurement Processes has been selected for the Basic profile.

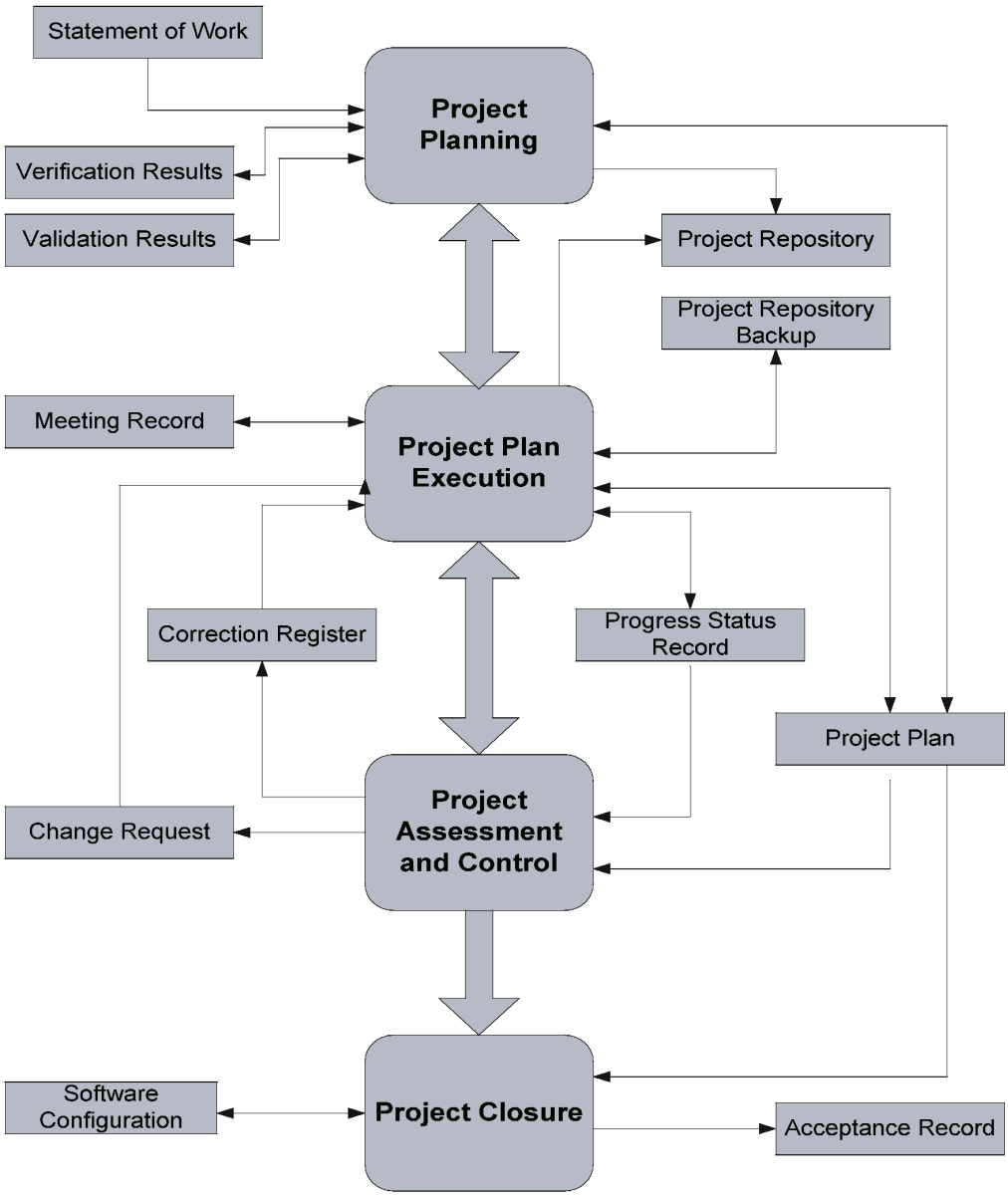
For illustration purposes, two tasks of the Project Planning activity are described in Table 13. On the left side of the table are listed the roles involved in a task: the project Manager (PM) and the Customer (CUS). Each task statement starts with an active verb to make sure that there is no ambiguity (e.g. versus 'Project Planning'), the artefacts needed to perform each task are listed as well as the output of each task. The status of input and output artefacts is also indicated.

The customer is also 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.

Table 13. Example of 2 tasks of the project planning activity (ISO, 2011b)

Role	Task list	Inputs	Outputs
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 5. Project management Process diagram for software (ISO, 2011b)



Management Process of the Engineering Organization

The project management practices used by the engineering division's project managers were assessed against the Entry and Basic profiles of ISO/IEC 29110 by interviewing project managers. Figure 7 shows the overall results of the assessment of the activities of the PM Process of the Entry profile. The figure displays the percentage of the tasks performed for each of the following activities of the ISO/IEC 29110 management and engineering guide (ISO, 2012):

Figure 6. Links between ISO/IEC/IEEE 12207 outcomes for Objective 1 of the PM Process (ISO, 2011b)

6.3.1 Project Planning Process
a) the scope of the work for the project is defined;
c) the tasks and resources necessary to complete the work are sized and estimated;
e) plans for the execution of the project are developed; and
f) plans for the execution of the project are activated.

6.3.7 Measurement Process
a) the information needs of technical and management processes are identified.

[ISO/IEC/IEEE 12207:2008, 6.3.1, 6.3.7]

- Project planning (11 tasks)
- Project plan execution (2 tasks)
- Project assessment and control (3 tasks)
- Project closure (2 tasks)

Table 14 illustrates the assessment of 2 of the 15 tasks of the Project Planning Activity of the Basic profile. As illustrated in this table, not only each task was evaluated, but a Low/Medium/High implementation priority was assigned as well as an estimation of the implementation effort and impact.

Figure 8 shows the overall results of the assessment of the activities of the PM Process of the Basic profile. The figure displays the percentage of the tasks performed for each of the following activities of the ISO/IEC 29110 management and engineering guide (ISO, 2011b):

Figure 7. Assessment of project management Process against the ISO/IEC 29110 Entry profile

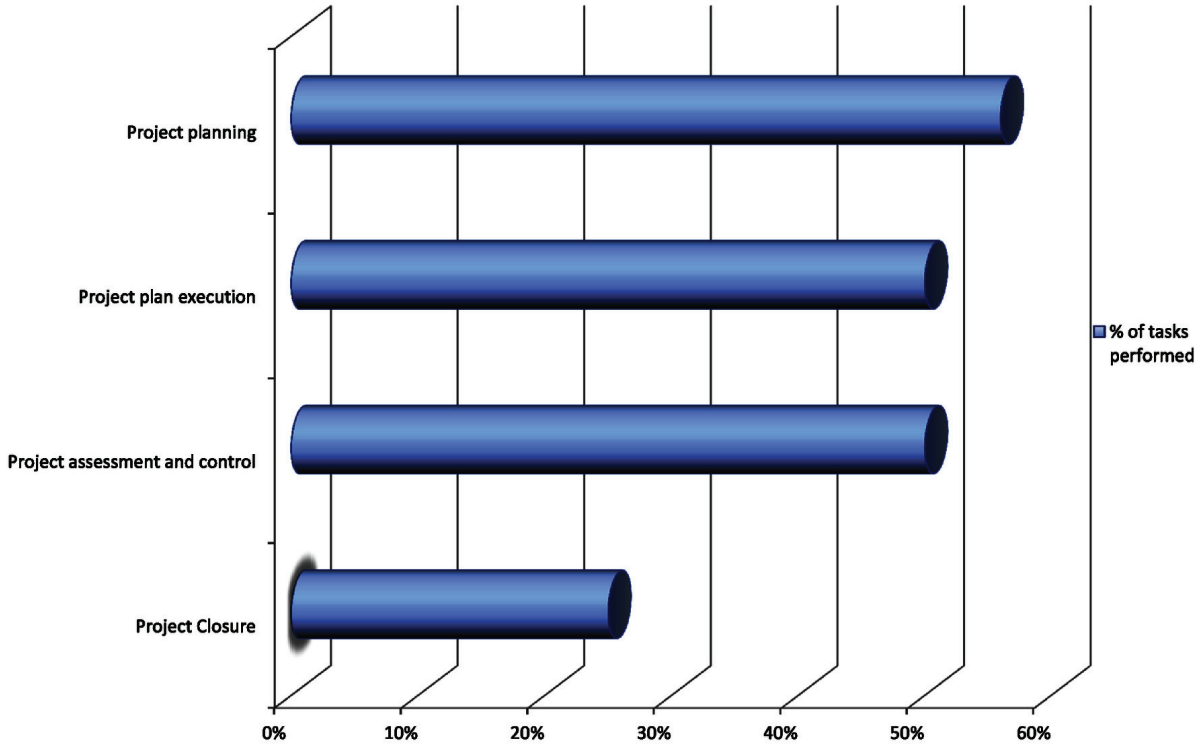
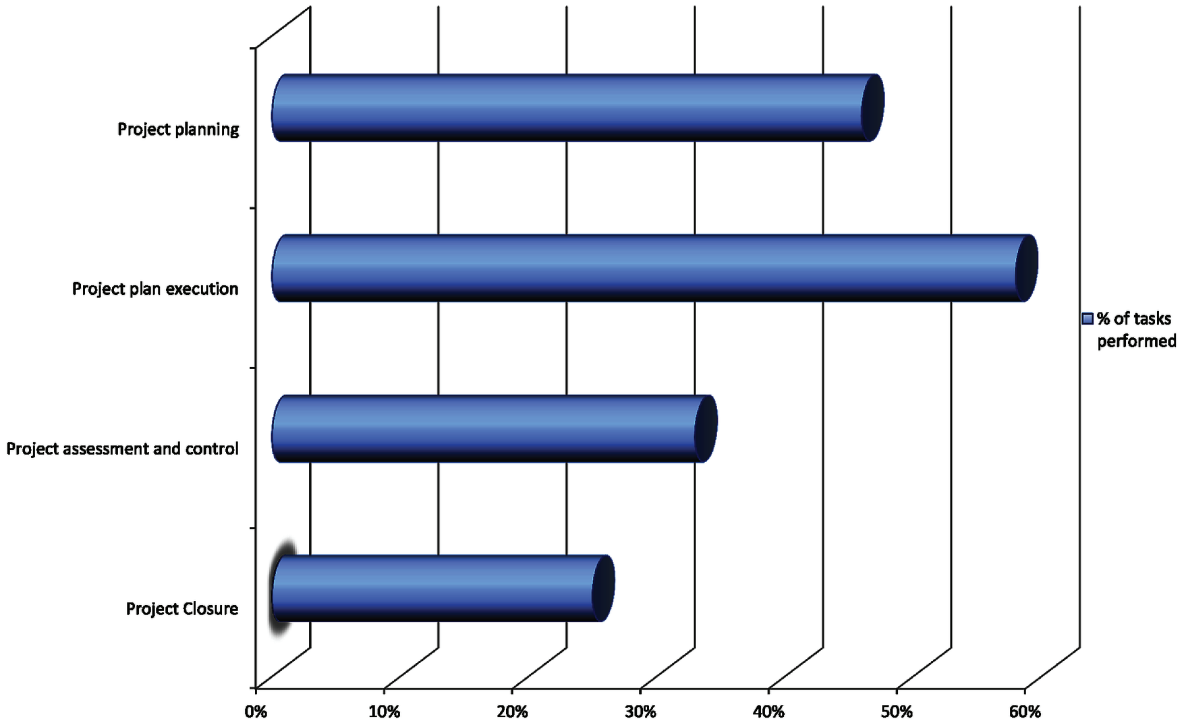


Table 14. Example of assessment of 2 of tasks the project planning activity against the Basic profile

ID	Roles	Tasks	Input Products	Output Products	Implemented	Implementation Priority	Implementation Effort	Implementation Impact
PM.1.1	PM TL	Review the Statement of Work	Statement of Work	Statement of Work [reviewed]	Partially	Medium	Low	Medium
PM.1.2	PM CUS	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	Partially	Medium	Low	Medium

Figure 8. Performance assessment against the Basic profile



- Project planning (15 tasks)
- Project plan execution (6 tasks)
- Project assessment and control (3 tasks)
- Project closure (2 tasks)

We note that a low level of implementation of ISO/IEC 29110 activities was achieved, for medium scale projects, within the engineering company at the beginning of the improvement program. Also, during the interview with managers, it was noted the PM tasks were not performed systematically. In addition, the assessment revealed that PM practices varied from project manager to project manager and that no guideline had been defined for a few tasks.

We note that the level of implementation of the project management tasks of the Basic profile is slightly lower than that of the Entry profile. This is explained by a higher number of tasks in the Basic profile. However, a significant gap remains between the profile and the current situation analyzed.

DEVELOPMENT OF THE PROJECT MANAGEMENT PROCESSES

The development of Processes and tools, such as checklists, templates and forms, was the central element of the solution to the problems identified. They have been developed taking into account the 3 categories of company projects.

Project Management Processes Developed

A Process is defined as a set of related activities that transforms inputs into output elements. The central element of the proposed solution is a project management Process guide. Three groups of project management Processes have been developed:

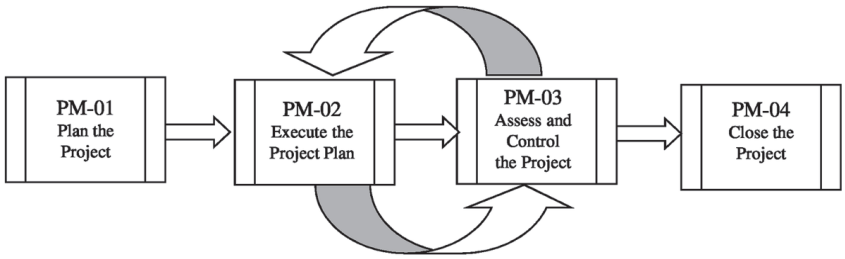
- Project management Process of small projects
- Project management Process of mid-sized projects
- Project management Process of large projects

Each project management Process is composed of 4 stages as illustrated in Figure 9.

A significant portion of projects undertaken by the company, about 70%, are small-scale projects with duration of less than four months with a team of less than five people. These projects have the following constraints:

- The completion dates are often too short to set-up a complex project management structure,
- The number of projects executed in parallel has a significant impact on the human resources assigned to them,
- Some project managers do not necessarily have all the required project management knowledge. They are very technically competent individuals who are assigned management tasks. They perform technical and management tasks.

Figure 9. Four stages of all project management Processes



The small-project project management Process was based on the Entry profile of the ISO/IEC 29110 standard. The medium-project project management Process was based on the Basic Profile. The large-project project management Process was improved and supplemented using the PMBOK® Guide of the Project Management Institute.

Notation Used to Document the Small- and Medium-Scale Processes

The ETVX notation (i.e. Entry-Task-Verification-eXit) was developed in the 80s by IBM (Radice & Roth, 1985). Given its simplicity to use, it has been adopted by many organizations such as NASA. Figure 10 describes an ETVX notation that was enriched by adding entry and exit criteria and measures.

This notation includes the following elements:

- Inputs
  - Elements received from outside the Process that are required for its execution. It is perhaps not mandatory that all inputs exist before starting activities in the Process. It is sometimes possible, for a first iteration, to use a subset of inputs. When the other inputs are available, further iterations may be performed.
- Tasks
  - Activities to be carried out to complete the Process and create the required artefacts. Usually, a task statement starts with an active verb and is followed with an object (e.g. Test code elements).
- Entry criteria
  - Criteria to ensure that the artefacts required for the tasks to be carried out meet quality criteria (e.g. Project budget has been approved)
- Exit criteria
  - Criteria to ensure that the tasks were carried out as required and that artefacts meet the quality criteria (e.g. Software Requirements have been reviewed and corrected)
- Outputs
  - Artefacts following the execution of the tasks that could be used in a next step of a Process.
- Measures
  - Measures collected during the execution of the tasks such as effort measured in hours, number of defects detected during a review.

Figure 10. Enriched ETVX Notation

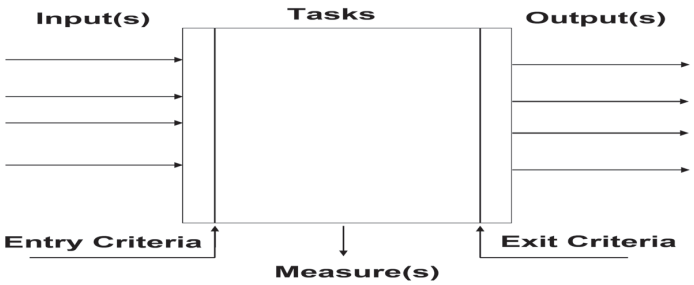


Figure 11 illustrates one step of the small-scale project management Process called plan the project. The identification of the Process is 'SPP' for Small-Scale Project; the title of the step of the Process is 'Plan the Project'. This step is composed of 6 tasks listed in the ETVX diagram.

It is also possible to use an enriched ETVX textual notation to describe a Process or a procedure. Figure 12 shows the template of this textual notation. This notation, as well as that of the figure above, could be used by an expert user.

A new user of a Process would require more information. As an example, each task would be described in more details such that it could be executed by new users and produce the same results. As an example, the task titled 'Estimate resources, effort and duration' could be enhanced by adding a detailed procedure showing, step by step, what has to be done.

Checklists Developed

Discussions with project managers of the organization revealed that they were often burdened with technical tasks in addition to the management of their project. This situation often impacted their ability to perform management tasks despite their level of expertise in project. It was therefore decided that a few checklists might provide a useful tool for project managers for the following reasons:

- They are a good way to explain or briefly summarize the tasks to be performed by the project manager
- They help identify quickly the forms and templates available to perform the project management tasks
- They provide quick links to additional references

Figure 11. Enriched ETVX description of a step of the project management Process

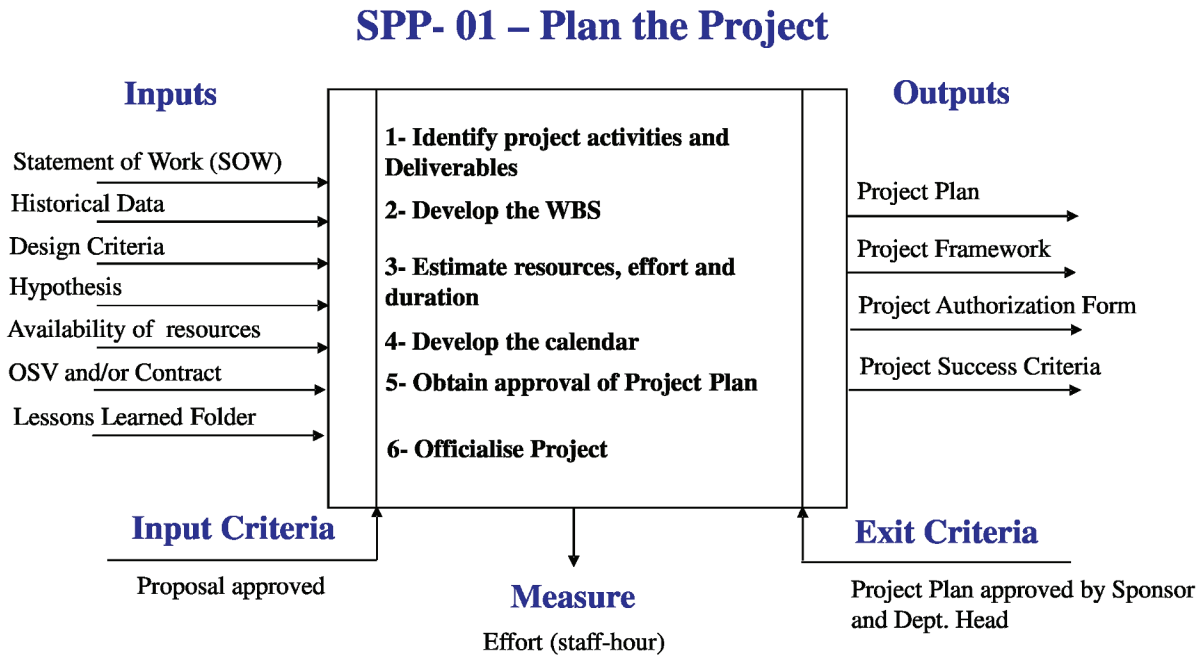


Figure 12. Textual representation of the enriched ETVX notation

Procedure: <Name of Process or Procedure>	**Phase:** <Name of phase where the procedure is used>
Process/Procedure Owner: <Owner of this process/procedure>	
Description: a brief description, background and purpose of the process/procedure	
Entry Criteria: • <entry criteria>	**Exit Criteria:** • <exit criteria>
Inputs: • <work products as input>	**Outputs**: • <work products as output>
Roles: • <list of all the actors and their responsibilities>	
Reference(s) • <Document required to use this procedure>	
Assets: • <Tools; methodologies; references; guidelines; checklists; other procedures>	
Tasks: • <Itemized list of tasks (summarized) which need to be accomplished to satisfy this process/procedure (using an active verb and a noun)>	
Measures: • <Measures captured during execution of process/procedure>	

- The provide guidance to the project manager for storing the project management documents
- They provide an easy means of assessing the implementation of Processes

As part of this project to improve management practices projects, five checklists were developed:

- Project management Process of small projects
- Project management Process of medium projects
- Project management Process of large projects
- Preparation of service offerings
- Preparation of detailed project planning

Project Management Forms and Templates Developed

Forms and templates were developed to guide Project Managers in the execution of management tasks and enable a consistency of results. They also serve to guide managers unfamiliar with some project management practices.

Testing Solutions Developed

To test the solutions developed, pilot projects have been performed. Checking solutions in the context of real project validated that the proposed solutions were consistent, feasible and complete. The small and medium Processes and tools have been tested. The pilot projects consisted of running three different projects where project managers implemented the Process and the associated tools.

Managers then evaluated the proposed Processes, identified problems and potential improvements. The lessons learned sessions conducted at the end of the pilot projects have identified minor adjustments to the Processes and tools. It was also noted, when executing the pilot projects that project managers would appreciate examples of how to implement the tools.

Developing a Deployment Strategy

Once the final adjustments were made to the project management Process and tools a strategy was developed for the deployment of these solutions to all project managers in the division, i.e. about thirty persons. The strategy consisted of the following three components: communication, training and diffusion of the Processes and their supporting documents.

The first phase was to inform project managers. In order to reduce questioning and to mitigate the negative impacts that 'unknown' can generate project changes, various means have been implemented to inform all managers. Here are some of them:

- Informative emails were sent;
- Articles were published in the monthly newsletter of the company;
- Informational messages have been added to the company intranet.

In addition, one-day training sessions have been prepared for project managers. The training allowed the project managers to learn the new Processes and tools developed.

The second phase was used to distribute documents to all managers of the division located in ten offices of the company in Canada. The most appropriate medium was the company's intranet. A section of the intranet, dedicated to project management, was created and served as a main access to project management documents such as project management Process guides, checklists, forms and templates. This section of the intranet also contains information relevant to project management as links to websites, the identification of project management standards and other information such as projects management books.

Table 15 lists a sample of the first projects that are or have been carried out by 4 project managers using the Processes and tools developed during the improvement project.

DAY-TO-DAY APPLICATION OF THE PROCESSES

After an agreement or a contract with a customer has been concluded, the selection of the project management Process must be made, by the project manager, using a spreadsheet tool containing the criteria listed in Figure 13. Once the appropriate project management Process has been selected, the sponsor of the project as well as by a Director or a Vice-President approve this selection.

Once the selected project management Process has been approved, it is applied in conjunction with the engineering Processes of the division. Figure 14 illustrates the day-to-day use of the project management Process and the relation with the knowledge management cycle. An organization can continually improve over time by learning from its success and its failures, and enhance the organizational performance in project management. Effective project management Process involves the identification, creation, acquisition, dissemination, and reuse of knowledge asset, i.e. lessons learned and best practices.

Table 15. First projects conducted using the Processes and tools developed

Project Budget (CAD$)	Process Used	Project Manager ID
120 000$	Medium-scale project	PM-1
27 000$	Small-scale project	PM-1
200 000$	Medium-scale project	PM-1
400 000$	Medium-scale project	PM-2
65 000$	Medium-scale project	PM-2
130 000$	Medium-scale project	PM-2
250 000$	Medium-scale project	PM-2
6 000$	Small-scale project	PM-1
40 000$	Small-scale project	PM-4
38 000$	Small-scale project	PM-5

Figure 13. Tool developed to select the appropriate PM Process

Project Management Process Selection Tool
To be completed for all projects

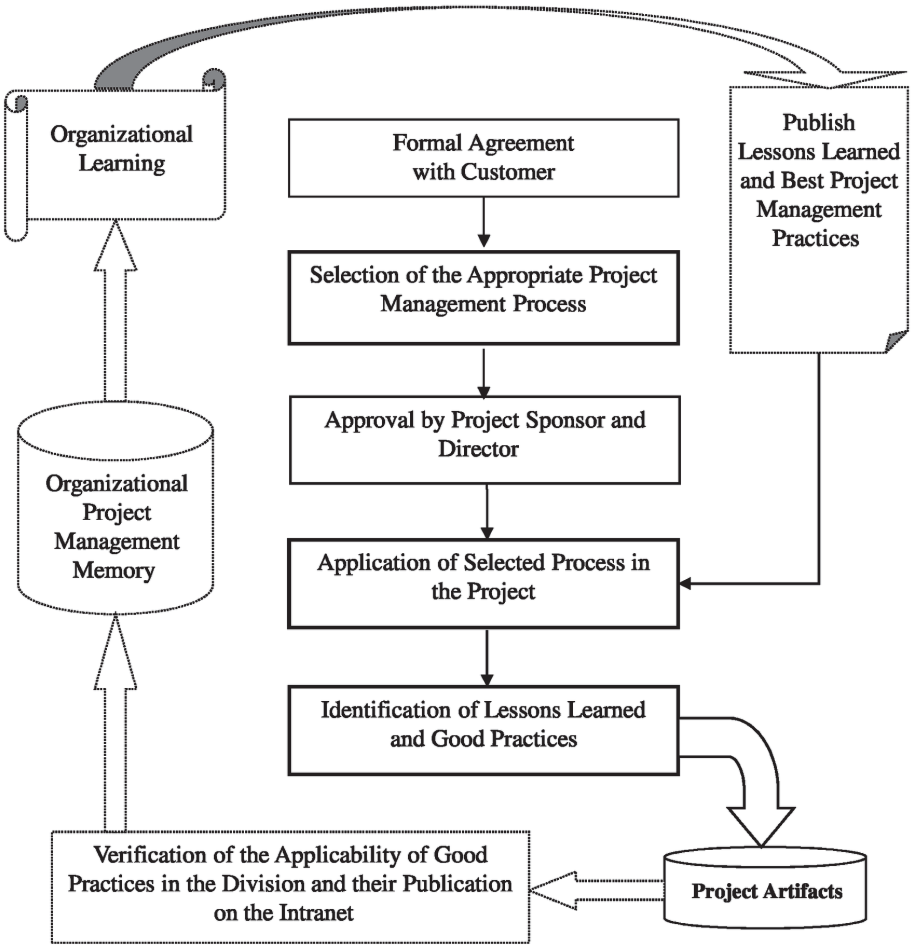
PROJECT TITLE: _____
CUSTOMER: _____
PROJECT MANAGER: _____
DATE: _____ PROJECT NUMBER: _____

Criteria					SMALL-SCALE PROJECT	MEDIUM-SCALE PROJECT	LARGE-SCALE PROJECT
1	DURATION	Lenght of engineering project (in months)	0	Months	Less than 2 months 0	Between 2 and 8 months 0	Over 8 months 0
2	SIZE OF PROJECT	Number of persons in project team	0	Persons	Equal or Less than 4 persons 0	Between 4 and 8 Persons 0	Over 8 persons 0
3	NUMBER OF ENGINEERING DISCIPLINES	Number of engineering disciplines in the project	0	Disciplines	1 Discipline 0	One or more engineering disciplines 0	Many disciplines 0
4	ENGINEERING FEES	Engineering Fees (CAD$)	0	$	Between 5 000$ and 70 000$ 0	Between 50 000$ and 350 000$ 0	More than 350 000$ 0
5	RISK LEVEL	Risk Level (when preparing the Proposal)	0	Green (1) Yellow (2) Orange (3) Red (4)	Green and Yellow only 0	All Levels 0	All Levels 0
	TOTAL				0	0	0
	Available Processes				0	0	0
	Selected PM Process	SSP					
	Signature of Person approving						
	Name of person approving	Project Sponsor				Service Director	

COST AND BENEFITS ANALYSIS OF THE USE OF ISO/IEC 29110 IN THE PROJECT MANAGEMENT PROCESSES

As discussed above, since a standard is a document describing knowledge and recognized practices about a specific domain, it should be possible to systematically assess the cost of its implementation and, more importantly, the economic benefits of its implementation. ISO has sponsored the development of a methodology to quantitatively assess the contribution of standards, consensus-based standards as well as company standards, to corporate value creation. The ISO methodology does not consider the negative impacts of the implementation of standards in an organization. The ISO methodology's main objectives are to provide (Gerundino & Hilb, 2010):

Figure 14. Day-to-day application of the PM Processes



- A set of methods to measure the impact of standards on organizational value creation (with an emphasis on businesses)
- Decision-makers with clear and manageable criteria to assess the value associated with using standards
- Guidance on developing studies to assess the benefits of standards within a particular industry sector.

The methodology addresses the following key questions (Gerundino & Hilb, 2010):

- What is the contribution of standards to corporate value creation?
- How do industry and company specifics impact corporate value creation arising from standards?
- How can companies maximize the value generated by standards?

The approach used by the engineering division, to estimate the cost and benefits, comprised four steps:

- Understanding the company's value chain
- Analyzing the value drivers
- Determining the impacts of standards
- Assessing and consolidating results

The four steps of the ISO methodology are described below.

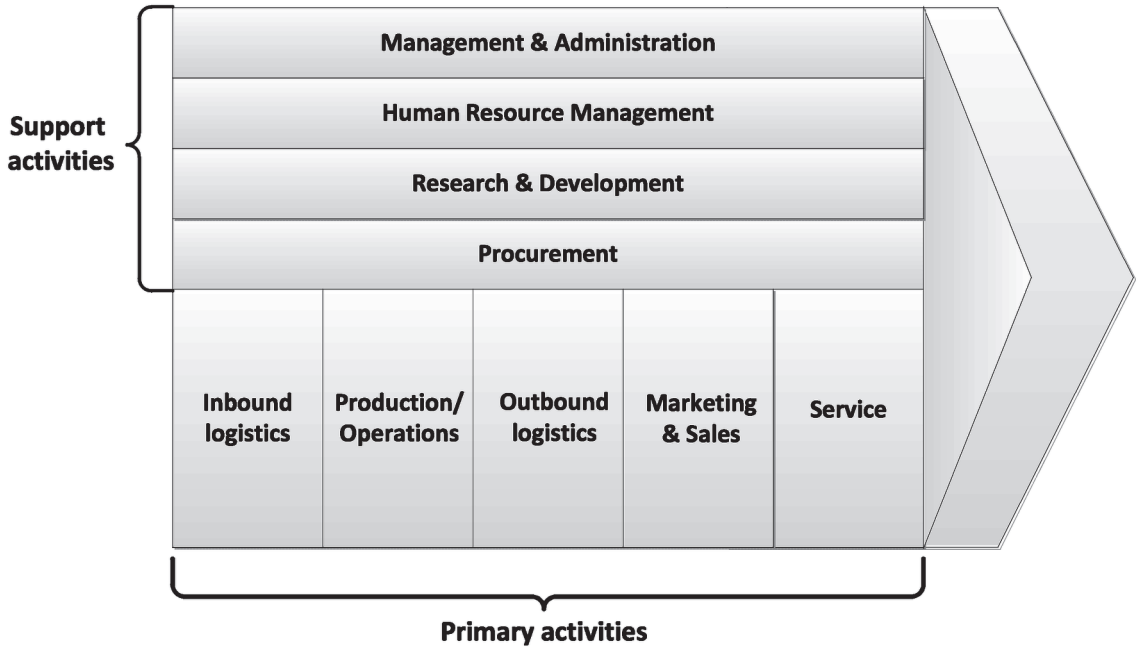
Step 1: Understanding the Company's Value Chain

The "value chain" is a concept described by Michael Porter of the Harvard Business School (Porter, 2008). Porter describes the value chain as a tool to understand the competitive advantage that a company can have in the actions it undertakes. The value chain is a representation of the different steps for an organization to create value in the form of goods or services to customers.

The performance of an activity can have an impact on cost and create a differentiation from competitors. Hence the advantage of using this tool to determine the impact of the project management improvement project to improve project management practices of the engineering division. Figure 15 illustrates the value chain of the company according to Porter's model. The vertical activities produce the main outputs of an organization while support activities displayed horizontally, such as procurement, influence and assist the primary activities.

In this model, the competence domains of an engineering division of the company are:

Figure 15. Value chain of the engineering division (adapted from ISO, 2010)



- Operations;
  - detailed engineering including the design of plans and specifications;
  - engineering linked to the achievement of specialized studies.
- Marketing and sales;
  - activities related to business development;
  - the development of contractual agreements;
  - assessment of services.
- Service
  - activities related to procurement of construction and installation phases of a project;
  - monitoring of construction and implementation activities;
  - activities related to the management of strategic assets.

Step 2: Analyzing the Value Drivers

After discussing with the company's governance board, the elements shown in Table 16 were identified as the main value drivers for the engineering consulting firm. The importance (i.e. important (3), largely important (2), very important (1)) of each driver was also determined.

Step 3: Determining the Impacts of Standards

The objective of this step was to identify the significant impacts that the improvement project will have on the company. Impacts were selected from the "Standards Impact Map" of the ISO methodology. Table 17 illustrates these impacts for the production category, similar tables were also developed for marketing and service categories. The links between the impacts of standards and the performance indicators identified in the previous step are also presented.

Table 16. Table of value drivers

Value Driver	Description	Performance Indicators	Importance
Quality of the design Process	Quality in terms of execution time, costs and quality of deliverables	Time spent on corrective engineering work. Cost overruns related to quality control.	Very important (company viability)
Efficiency versus costs	Ability to complete the work at minimum cost	Meeting budgets allocated to each sub-project. Meeting overall project budget.	Very important (company viability)
Project management capacity	Capacity to manage projects according to plans	Cost Performance Index (CPI)	Very important (completing projects is the company's core activity)
Technical expertise	Ability to solve complex problems	Schedule Performance Index (SPI)	Important
Geographic positioning	Geographic proximity of customers	Resource usage time (e.g. overtime)	Average importance
Partnership	Capacity to initiate partnerships with other companies	Number of partnerships Recurring customers	Average importance
Flexibility	Capacity to adapt to different customer needs	Number of services provided Type of service compared with competitors	Important

Table 17. Impacts of standards

Category	Activity	Impact ID	Impact Title	Description	Priority [1-high, 3-low]	Performance Indicator
Operation (P)	All activities	P-1	Improvement of internal information transfer	The use of standardized documents and specifications allows a more efficient transfer of information internally	2	- Meeting budget allocated to each sub-project. - Meeting overall project budget - Cost performance index (CPI)
		P-2	Better training of staff	Staff can be better trained due to the standardization of Processes	3	-Meeting budget allocated to each sub-project. - Meeting overall project budget -Cost performance index (CPI).
		P-3	Additional cost of staff	Increased costs due to the implementation of Processes	1	-Cost of the Process improvement project
	Execution	P-4	Better quality of deliverables	Better quality of deliverables based on standardization of Processes which reduce errors and rework costs	1	-Time spent on reworking engineering products -Cost overruns required for quality control.
	Quality Assurance	P-5	Better management of quality	Management of quality can be implemented more efficiently due to the standard.	1	-Time spent on reworking engineering products. -Cost overruns required for quality control.
	Knowledge	P-6	More effective internal standardization	It is more efficient to implement standards which are defined on the basis of recognized standards compared to proceed with the development of own internal standards.	1	-Cost of the Process improvement project

Step 4: Assessing and Consolidating Results

During this final step, the identified impacts were analyzed and impacts were determined separately by two persons of the enterprise: the engineer responsible for the improvement project and his supervisor. Tables 18 to 20 illustrate these results of the estimation for the production category. Table 18 illustrates the financial impacts due to the use of standardized documents and specifications on the internal transfer of information.

Table 19 illustrates the Staff training impact on projects and cost of training.

Table 20 illustrates the financial impact due to the cost of the development of project management Processes and of the cost of training the project managers.

The expenses for the improvement of the project management practices were estimated at 59,600$ and the expected net gain before tax between were estimated, for the first year, to be between 250,900$ and 260,100$. Table 21 presents the expected savings over a period of one year estimated by the 2 evaluators.

Table 22 presents the cost estimates for the development and implementation of project management Process for the first year.

Implementation and maintenance costs were also estimated for year 2 and 3. Table 23 presents the costs over the first 3 years.

Table 18. Assessment of the financial impacts about the improvement of internal information transfer

Impact ID	Description of Impacts		Evaluator # 1	Evaluator # 2
Operation -1	**Improvement of Internal Information Transfer**			
	What is the overall cost overrun of projects?	Estimation based on the Profitability Report	555,500 $	555,500 $
	What percentage of the project was in trouble due to a problem of information transfer?		25%	20%
	How much does the project management Process can improve the transfer of information?		80%	75%
		Financial impact	**111,100 $**	**83,325 $**

Table 19. Staff training impact on projects and cost of training

Operation -2	Better Training of Staff		Evaluator # 1	Evaluator # 2
	What is the overall cost overrun of projects?		555,500 $	555,500 $
	What percentage of the projects had difficulties due to staff training?		20%	15%
	By how much (in percent) could the Process improvement project can improve staff training?		50%	50%
		Financial impact	**55,550 $**	**41,663 $**

Table 20. Financial impact due to the development of Processes and staff training

Operation -3	Additional Cost of Staff		Evaluator # 1	Evaluator # 2
	Costs of developing Processes and related documents	see Table 23 for details		
	Costs of staff training	see Table 23 for details		
		Financial impact	**- 59,600$**	**- 59,600$**

Table 21. Summary of the economic benefits for the first year of utilization

Earnings Before Interest and Taxes Evaluation	Evaluator # 1	Evaluator # 2
Operation	201 485 $	162 600 $
Marketing	49 438 $	97 500 $
Service	0 $	0 $
Total	**250 923 $**	**260 100 $**

Table 22. First year estimation of implementation costs

		Year 1	
Category	**Description**	**Schedule Estimation (hour)**	**Cost Estimation ($ CAD)**
Communication			
	Company Newsletter (2)	40	4000
	Official communication to use the Processes (3)	40	4000
	Official communications of updated Processes (2/year)	0	0
Pilot Projects			
	Secretarial support	40	3000
Employee training			
	Trainer	80	9600
	Participants (30 persons x 8h) – Initiation to Processes	240	28800
	Participants (30 persons x 4h) - Update	0	0
	Secretarial support	40	3000
Reserve			
	Reserve of 15% (100$/hour)	72	7200
	Total	**552 hours**	**59,600 $**

Table 23. Costs over the first 3 years of implementation

		Year 1	Year 2	Year 3
Cost Category	**Description**	**Cost Estimation**	**Cost Estimation**	**Cost Estimation**
Communication				
	Company Newsletter (2)	4,000	4,000	4,000
	Official communication to use the Processes (3)	4,000	0	0
	Official communications of updated Processes (2/year)	0	2,000	2,000
Pilot Projects				
	Secretarial support	3,000	1,500	1,500
Employee Training				
	Trainer	9,600	4,800	4,800
	Participants (30 persons x 8h) – Initiation to Processes	28800	14,400	14,400
	Participants (30 persons x 4h) - Update	0		
	Secretarial support	3,000	3,000	3,000
Reserve				
	Reserve of 15% (100$/hour)	7,200	6,000	6,000
	Total	**59,600 $**	**50,100$**	**50,100$**

Assessing and Consolidating Results

The most significant impacts of the improvement program on the company were then selected based on the Standards Impact Map of the ISO Methodology. Table 24 provides an example of such impacts. The link between the impacts of standards used and the performance indicators identified during the previous step are also shown in this table.

An estimate of anticipated costs and benefits over a period of three years was done by the improvement program project sponsors. Table 25 shows the results for the first three years.

The 400-person Canadian division has evaluated five potential project management frameworks and has selected the most appropriate one for its business context as well as a function of existing assets. The effort invested in the selection, documentation and deployment of the small and medium-scale project management Processes and support tools was costly but, without an appropriate selection of the framework, the development of a set of tools and their wide deployment on the intranet, the division would not have been able to achieve the business goals listed in Table 4 as well as the benefits listed in Table 25.

NEXT STEPS

Since the utilization of ISO/IEC 29110 was very successful in the development project management Processes, the recently published systems engineering ISO/IEC 29110, described below, will be used by the engineering division to redefine and improve its existing engineering Process. This Process will address the activities required from engineering requirements identification to final product delivery.

The systems engineering Basic profile, as illustrated in Figure 16, like the software engineering Basic profile, is composed of two Processes: a Project Management (PM) Process and a System definition and

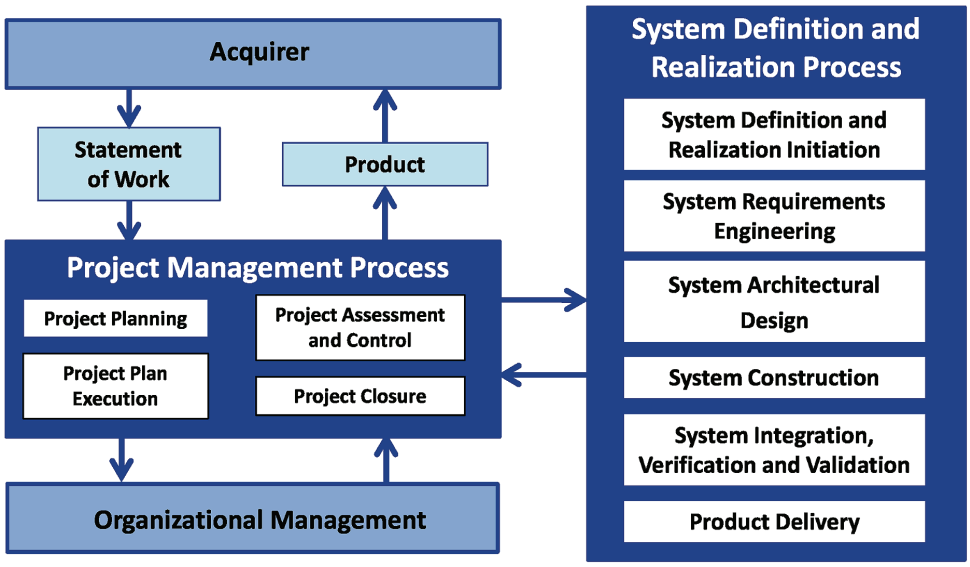
Table 24. Example of impacts of ISO/IEC 29110

Functions	Activities	Impact number	Impact	Description	Prioritization [1-high, 3-low]	Performance indicator
Production	All activities	P-1	Better internal information transfer	The use of standardized documents and specifications enables a more efficient internal information transfer.	2	Meeting budgets allocated to each sub-project. Meeting overall project budget. Cost performance indicators (CPI)

Table 25. Anticipated costs and benefits from the improvement program ($ CAD)

	Year 1	Year 2	Year 3	Total
Implementation and maintenance costs	59,600$	50,100$	50,100$	159,800$
Net benefits	255,500$	265,000$	265,000$	785,500$

Figure 16. Processes and activities of the systems engineering Basic profile (Laporte et al., 2014 c)



Realization (SR) Process. As defined in ISO/IEC 29110, the purpose of the Project Management (PM) Process is to establish and carry out in a systematic way the tasks of the system development, which allows complying with the project's objectives in the expected quality, time and cost.

The purpose of the System Definition and Realization (SR) Process is the systematic performance of the analysis, design, construction, integration, verification, and validation activities for new or modified system according to the specified requirements.

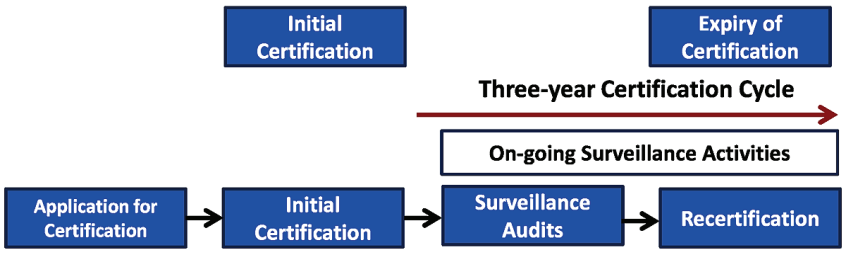
So far, one Canadian organization has implemented the Basic profile of the systems engineering ISO/IEC 29110: a 10-person start-up VSE in public transportation (Tremblay, 2012). The company, which began operations in 2011, specializes in the integration of interactive systems, communication and safety in the field of public transportation for trains, subways and buses as well as stations and stops. ISO/IEC 29110 standard for systems engineering has been used as the main reference for the development of its Processes.

ISO/IEC 29110 Certification of VSEs

VSEs requested in the WG24 survey described above, a mean to be recognized internationally. For VSEs, international certifications can enhance credibility, competitiveness and access to national and international markets. For VSEs, such a certification should not be too expensive and short. The ISO/IEC 29110 certification scheme, as illustrated in Figure 17, it is a four-stage certification Process.

Bit Perfect, a Peruvian VSE of 4 people created in 2012, was successfully audited in 2014 by a Brazilian auditor. The VSE provides software development services and automation of business Processes with information systems solutions. During its first two years of existence, the VSE has been involved in over 80 projects of which most have been lasted less than two months. The VSE used agile practices to

Figure 17. ISO/IEC 29110 Four-Stage Certification Process (Laporte 2014b)



implement software solutions. The VSE of 4 people implemented the Project Management Process and the Software Implementation Process of the Basic profile of ISO/IEC 29110 (Garcia et al., 2015). The VSE spent about 22 hours for Phase 1 of the certification Process. The VSE spent 63 hours for Phase 2 of the certification Process. The total cost of the audit was about $1,500. For a VSE, the effort and cost are considerably lower than the cost of conducting an assessment using a framework such as the CMMI®.

CONCLUSION

The new ISO/IEC 29110 standard enabled an engineering consulting firm to develop project management Processes for their small-scale and medium-scale projects that offered a structured approach to its project managers. The actions required by such Processes are restricted to the most essential ones, in order to limit the management effort per project.

The tools developed to support the project management Processes proved very useful and helped the project managers rapidly integrate the knowledge required to execute the Processes.

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 program 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.

Since the utilization of ISO/IEC 29110 was very successful in the development project management Processes, the systems engineering ISO/IEC 29110, published in 2014, will be used to redefine and improve the existing engineering Process of the Canadian division of the American engineering company. This Process will address the activities required from engineering requirements identification to final product delivery.

The management of the 400-person division has used an engineering approach to this project management Process development. It has treated the project as any other industrial project performed by their staff in assessing the context, selecting the framework and developing and deploying the Process and its associated support tools. As indicated by Garcia « When an organization selects a standard that fits its context well, and plans the adoption thoughtfully, it's most likely to achieve the standard's advertised benefits » (Garcia, 2005).

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KEY TERMS AND DEFINITIONS

Basic Profile: A profile that describes development practices of a single application by a single project team of a very small entity (ISO/IEC TR 29110-1:2011 Software engineering-Lifecycle profiles for Very Small Entities (VSEs)-Part 1: Overview).

Certification: A third-party attestation related to products, Processes, systems or persons (ISO/IEC 17000).

Entry Profile: A profile targeted at very small entities working on small projects (e.g. at most six person-months effort) and for start-ups (ISO/IEC TR 29110-1:2011 Software engineering-Lifecycle profiles for Very Small Entities (VSEs)-Part 1: Overview).

Micro-Enterprise: An enterprise having up to 9 employees.

Generic Profile Group: A profile group applicable to VSEs (very small entities) that do not develop critical systems or software products and have typical situational factors (ISO/IEC TR 29110-1:2011 Software engineering-Lifecycle profiles for Very Small Entities (VSEs)-Part 1: Overview).

Process: System of activities, which use resources to transform inputs into outputs (ISO/IEC 25000:2014 Systems and software Engineering--Systems and software product Quality Requirements and Evaluation (SQuaRE) - Guide to SQuaRE, 4.41).

Process Notation: Means of concrete representation for a particular type of a model, expressed as a grammar and suitable glyphs for its terminal symbols (ISO/IEC 10746-2:2009 Information technology -- Open Distributed Processing - Reference Model: Foundations, 7.5).

Profile: A set of one or more base standards and/or profiles, and where applicable, the identification of chosen classes, conforming subsets, option and parameters of those base standard, or standardized profiles necessary to accomplish a particular function. (ISO/IEC TR 29110-1:2011 Software engineering-Lifecycle profiles for Very Small Entities (VSEs)-Part 1: Overview).

Project Management: The application of knowledge, skills, tools, and techniques to project activities to meet the project requirements (A Guide to the Project Management Body of Knowledge (PMBOK® Guide) - Fifth Edition, 2013).

Software Engineering: The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software (ISO/IEC/IEEE 24765:2010 Systems and software engineering -Vocabulary). On-line vocabulary: http://pascal.computer.org/sev_display/index.action.

Standard: Document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context (ISO/IEC TR 29110-1:2011 Software engineering-Lifecycle profiles for Very Small Entities (VSEs)-Part 1: Overview).

Systems Engineering: An interdisciplinary approach governing the total technical and managerial effort required to transform a set of customer needs, expectations, and constraints into a solution and to support that solution throughout its life (ISO/IEC 15940:2013 Systems and software engineering-Software Engineering Environment Services).

Very Small Entity: An enterprise, an organization, a department or a project having up to 25 people (ISO/IEC TR 29110-1:2011 Software engineering-Lifecycle profiles for Very Small Entities (VSEs)-Part 1: Overview).

ENDNOTES

[1] International Organization for Standardization/ International Electrotechnical Commission Joint Technical Committee 1/ Sub Committee 7.

[2] The table describes information extracted and adapted from web sites of organizations which have developed the frameworks (e.g. Project Management Institute, Software Engineering Institute and International Organization for Standardization).