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Systems and Software Engineering Standards for Very Small Entities

Implementation and Initial Results

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***Abstract*—Very small entities, organizations with up to 25 people, are very important to the worldwide economy. However it has ben established that such companies often do not utilize existing best practice standards and frameworks. To address the needs of Very Small Entities (VSEs), a set of international standards and guides known as ISO/IEC 29110 has been developed. In this paper we present the results of early trials of this standard in an IT start-up and in an engineering enterprise and assess the lessons learnt for future research and industrial usage of this standard.**

Keywords—ISO Standards, ISO/IEC 29110, VSE

I. INTRODUCTION

Industry recognizes the value of Very Small Entities (VSEs), i.e., enterprises, organizations, departments or projects with up to 25 people, in contributing valuable products and services. A large majority of enterprises worldwide are VSEs. The term VSE has been defined as being "an enterprise, organization, department or project having up to 25 people" [1]. VSEs have unique characteristics, which make their business styles different to SMEs and therefore most of the management processes are performed through a more informal and less documented manner [2]. Furthermore there is an acknowledged lack of adoption of standards in small and very small companies, as the perception is that they have been developed for large software companies and not with the small organisation in mind [3]. Accordingly the new standard ISO/IEC 29110 "Lifecycle profiles for Very Small Entities" is aimed at meeting the specific needs of VSEs [4]. The overall objective of this new standard is to assist and encourage very small software organizations in assessing and improving their software process and it is predicted that this new standard could encourage and assist small software companies in assessing their software development process. The approach [5] used to develop ISO/IEC 29110 started with the pre-existing international standards, such as the software life cycle standard ISO/IEC/IEEE 12207 and the documentation standard ISO/IEC/IEEE 15289.

There is a wide spectrum of development approaches for organizations developing software. Figure 1 illustrates the spectrum of approaches on 2 axes. On the horizontal axis, from left to right, is illustrated the level of ceremony, from a low ceremony approach with little documentation (e.g. agile approach) to a high ceremony approach with a comprehensive documentation (e.g. plan driven CMMI approach). On the vertical axes are illustrated the approaches based on the level of risk. The top 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. As we will explain below, ISO/IEC 29110 is located at about the centre of both axes.

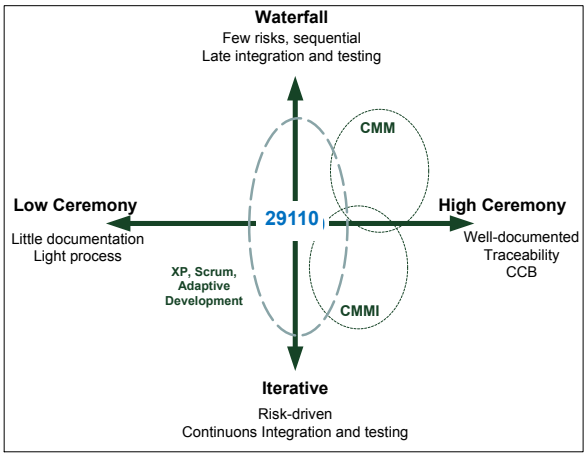

Fig. 1. Positioning of the ISO/IEC 29110 (adapted from Kroll 2003)

The working group behind the development of this standard is advocating the use of pilot projects as a mean to accelerate the adoption and utilization of ISO/IEC 29110 by VSEs [6]. Pilot projects are an important mean of reducing risks and learning more about the organizational and technical issues associated with the deployment of new software engineering practices [7]. To date a series of pilot projects for the software engineering profile standard have been completed in several

countries with the results published in a variety of literature [8, 9, 10].

II. INTERNATIONAL STANDARDS FOR VSES

A. Development

Since an international standard dedicated to the software life cycle processes was already available, i.e. ISO/IEC/IEEE 12207 [11], WG24, the ISO/IEC JTC1 SC7[1] working group mandated to develop the new set of standards for VSEs, used the concept of ISO standardized profiles (SP) to develop the new standards for VSEs developing software. From a practical point of view, a profile is a kind of matrix which identifies precisely the elements that are taken from existing standards from those that are not. The overall approach followed by WG24 to develop this new standard for VSE consisted of the following steps:

- develop a set of profiles for VSEs not involved in critical software development,
- select the ISO/IEC/IEEE 12207 process subsets applicable to VSEs having up to 25 people,
- select the description of the products, to be produced by a project, using ISO/IEC/IEEE 15289 standard [12],
- develop guidelines, checklists, templates, examples to support the subsets selected.

B. Generic Profile Group

Profile Groups are a collection of profiles. The Generic Profile Group has been defined as applicable to a vast majority of VSEs that do not develop critical systems or critical software. This Profile Group is a collection of four profiles (Entry, Basic, Intermediate, Advanced) providing a progressive approach to satisfying a vast majority of VSEs. 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 software 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 target to VSEs which want to sustain and grow as a competitive software development business. Table 1 illustrates this profile group as a collection of four profiles, providing a progressive approach to satisfying the requirements of a profile group, where each profile graduates and builds upon the tasks and activities of earlier profiles.

TABLE I. GRADUATED PROFILES OF THE GENERIC PROFILE GROUP

Generic Profile Group			
Entry	Basic	Intermediate	Advanced

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

Generic Profile Group			

The ISO/IEC 29110 standards and technical reports targeted by audience are described in Table 2. The set of documents, listed in table 2, for the Basic profile ([13-17] were published in 2011. At the request of WG24, all ISO/IEC 29110 TRs are available at no cost from ISO (http://standards.iso.org/ittf/PubliclyAvailableStandards/index.html). The Management and Engineering Guide, the most valuable document for VSEs, has being translated in French and in Spanish by Peru and adopted as a Peruvian national standard. The set of 5 documents has been translated in Portuguese by Brazil and adopted as a Brazilian national standard. The set of 5 documents has been translated in Spanish by Uruguay and adopted as a national standard. Japan has translated and adopted ISO/IEC 29110 as a Japanese national standard. The Management and Engineering guide of the Entry profile has been published in English [16], in French [17] and in Spanish [20].

TABLE II. ISO/IEC 29110 TARGET AUDIENCE

Part	**Title**	**target**
1	Overview	VSEs, customers, assessors, standards producers, tool vendors, and methodology vendors.
2	Framework and taxonomy	Standards producers, tool vendors and methodology vendors. Not intended for VSEs.
3	Assessment guide	Assessors, customers and VSEs
4	Profile specifications	Standards producers, tool vendors and methodology vendors. Not intended for VSEs.
5	Management and engineering guide	VSEs and customers

C. Overview of the Basic Profile for VSEs developing software

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

and the Project Management processes are illustrated in Figure 2.

As illustrated in figure 2, the customer's statement of work (SOW) is used to initiate the PM process. The project plan will be used to guide the execution of the software requirements analysis, software architectural and detailed design, software construction, and software integration and test, and product delivery activities. The PM process closure activity will deliver the Software Configuration (i.e. a set of software products such as documentation, code and tests) and will obtain the customer's acceptance to formalize the end of the project.

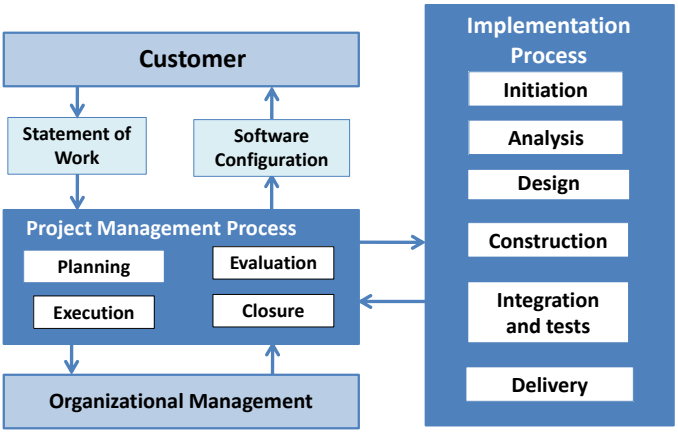

Fig. 2. Basic profile processes and activities

TABLE III. EXAMPLE OF 2 TASKS OF THE PROJECT PLANNING ACTIVITY

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]*

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.

D. Development of Deployment Packages

A novel approach was taken to assist VSEs with the deployment of ISO/IEC 29110 and to provide guidance on the actual implementation this standard. A set of Deployment Packages (DPs) have been developed to define guidelines and explain in more detail the processes defined in the ISO/IEC 29110 profiles [21]. The elements of a typical DP are: description of processes, activities, tasks, steps, roles, products, templates, checklists, examples, references and mapping to standards and models, and a list of tools. The mappings show that a deployment package has explicit links to standards, such as ISO/IEC/IEEE 12207, or models, such as the CMMI for Development. Hence by implementing a DP, a VSE can see its concrete step to achieve or demonstrate coverage [22].

DPs were designed such that a VSE can implement its content, without having to implement the complete ISO/IEC 29110 framework, i.e. all the management and engineering activities, at the same time. A set of nine DPs have been developed to date and are freely available from [23]. Figure 3 illustrates the set of DPs developed to support the Basic Profile. The set of DPs has been translated in Spanish and was used by students when implementing ISO/IEC 29110 in Latin America.

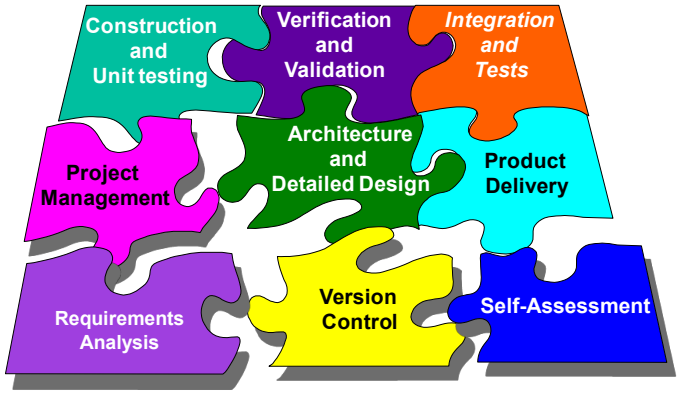

Fig. 3. DPs support for Basic Profile [29]

A first commercial software solution using the DPs has been developed to facilitate the implementation of the Basic profile. The tool (http://nuumsolutions.com/?location=29110) which is based on the well-known Atlassian tool suite, facilitates the role of the project manager and enhances team collaboration. It has the following characteristics:

- Project artefacts are shared in one place;
- Project documentation is managed;
- A project progress dashboard can be generated;
- Integrated with model-based solutions.

The solution provides project artefacts and documentation templates. It enforces the management and engineering processes, and it facilitates progress tracking (e.g. traceability). When using a model-based approach, project artefacts such as

requirements, tests, changes and models can be integrated and traced. The solution will be available in several languages, including English, French and Spanish.

E. The Development of systems engineering standards and guides for VSEs developing systems

In 2009, an INCOSE (International Council on Systems Engineering) working group was established to evaluate the possibility of developing a standard using the Generic profile group scheme of the ISO/IEC 29110 series and the systems engineering lifecyle processes standard ISO/IEC/IEEE 15288 [24], for organizations developing systems. This new ISO/IEC 29110 standard is targeted at VSEs which do not have experience or expertise in tailoring ISO/IEC/IEEE 15288 to their needs.

In November 2011, WG24 met in Ireland to launch the official development of the systems engineering ISO 29110 ISs and TRs for VSEs. Delegates from Brazil, Canada, France, Japan, Thailand, United States and INCOSE participated to the first meeting. A first draft was sent for a round of review within ISO in January 2012. Over 450 comments have been submitted by 7 countries. A second draft [25] was sent for a second round of review in December 2012. Less than 150 comments have been submitted and processed. The Management and engineering guide for the Basic Profile has been published by ISO in 2014. A set of systems engineering DPs has been developed by systems engineers, members of INCOSE, to support the Basic Profile.

III. IMPLEMENTATION TRIALS

In this section we will present 2 trial implementations of ISO/IEC 29110. The purpose of these trials is to illustrate the usage of this standard in an industrial context and to provide feedback to standards authors. Whilst not a detailed methodological approach to validation of this standard and whilst acknowledging the validation limitations, we believe that these high level results are useful to researchers and practitioners alike.

A. Implementation in an IT start-up enterprise

An implementation project has been conducted in an IT start-up VSE by a team of two (part-time) developers. Their web application allows users to collaborate, share and plan their trips simply and accessible to all. The use of the Basic profile of ISO/IEC 29110 has guided the start-up to develop an application of high quality while using proven practices of ISO 29110. The total effort of this project was nearly 1000 hours. The two members of the team were assigned roles and activities of ISO 29110. Table 4 illustrates how the roles of ISO 29110 were allocated to the team.

TABLE IV. ALLOCATION OF ISO 29110 ROLES TO THE 2-MEMBER TEAM (TRANSLATED FROM [26])

Role	**Identification**
Analyst	A
Designer	B
Programmer	A/B
Project Manager	B
Technical Leader	A
Work Team	A/B

ISO 29110 list the documents and their typical content which have to be developed during a project. Table 5 lists, for most documents, which team member was either an author or a reviewer.

During the software development, a traceability matrix was developed between the software requirements, defined in the requirements specification document, and the software components. Since, in most projects requirements, defined in the requirements activity, are never finalized at the end of this activity, a traceability matrix is very useful. One advantage of such a matrix is the possibility of rapidly identifying the impacted software components when modifications, additions, deletions, of software requirements are done during a project.

TABLE V. DISTRIBUTION OF RESPONSIBILITIES AS AN AUTHOR OR A REVIEWER (TRANSLATED FROM [26])

Document title	**Author**	**Reviewer**
Change Request	A	B
Correction Register	B	A
Maintenance Documentation	B	A
Meeting Record	A	-
Product Operation Guide	B	B
Progress Status Record	B	-
Project Plan	B	A
Project Repository	B	-
Project Repository Backup	B	-
Requirements Specification	A	B
Software	A/B	-
Software Components	A/B	-
Software Configuration	A/B	-
Software Design	B	A
Software User Documentation	A	B
Statement of Work	A	B
Test Cases and Test Procedures	A	B
Test Report	A	-
Traceability Record	B	A
Verification Results	A/B	-
Validation Results	A/B	-

Verification tasks, such as peer reviews, were performed on documents such as the requirement specifications and the architecture. The team used the desk-check to review their documents which is inexpensive and easy to implement in any organization and can be used to detect anomalies, omissions, improve a document or present and discuss alternative solutions.

As defined in ISO/IEC 29110, the software integration and tests activity ensures that the integrated Software Components satisfy the software requirements. This activity provides (ISO 2011c):

- Work team review of the project plan to determine task assignment.
- Understanding of test cases and procedures and the integration environment.
- Integrated software components, corrected defects and documented results.
- Traceability of requirements and design to the integrated software product.
- Documented and verified operational and software user documentations.
- Verified software baseline.

To manage the defects detected, a tracking tool was used. Such software allowed the team to do an inventory of problems found during the integration and testing activity, to track problems and to classify them, and to determine a priority for each defect found. In this project, the open source Bugzilla software tool had been used to manage the defects.

The test report presents the results of tests carried out using the test plan. These results are used to illustrate the number of problems found and the progress of the resolution of anomalies. The test plan includes 112 cases which have been successfully completed with the exception test cases connected to one type of defect: the validation of the date format when manually entered by a user. Since this defect was classified as "minor", it was decided not to correct their instances during the first cycle of development.

Figure 4 illustrates the percentage of defects detected during the execution of the tests for each category of defects.

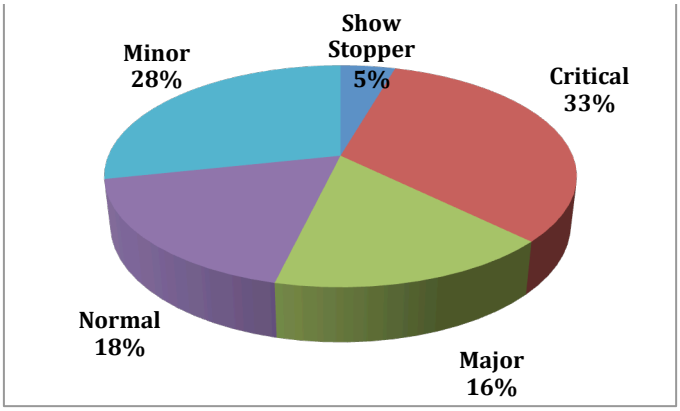

Fig. 4. Percentage of defects detected for each category of defects. (Translated and adapted from [26])

The defects classified by severity using the following defect classification:

- Blocker: prevents function from being used, no work-around, blocking progress on multiple fronts
- Critical: prevents function from being used, no work-around
- Major: prevents function from being used, but a work-around is possible
- Normal: a problem making a function difficult to use but no special work-around is required
- Minor: a problem not affecting the actual function, but the behaviour is not natural

The members of the start-up have recorded the effort, in person-hours, spent on tasks of the project to the nearest 30 minutes. Table 6 shows, for each major task, the effort to execute the task, the effort required to review a document, such as the software specification document, in order to detect errors and, the effort required to correct the errors (i.e. the rework). As an example, for the development of the software architecture document, it took 42.5 hours to develop, an additional 1.5 hour to conduct a review and an additional 3.5 hours to correct the errors.

TABLE VI. EFFORT TO EXECUTE, DETECT AND CORRECT ERRORS BY THE 2-MEMBER TEAM (TRANSLATED AND ADAPTED FROM [26])

Title of task	Prevention (hours)	Execution (Hours)	Review (Hours)	Rework (Hours)
Environment installation	89			
Project plan development		35	3	4
Project plan execution and project assessment & control		47		
Specification & prototype development		199.5	7	18
Architecture		42.5	1.5	3.5

development				
Test plan development		12.5	1	2
Code development and testing		361	47	96.5
Develop user guide & maintenance document		8	1	1
Web site deployment		8.5		
Project closure		2		
Total hours	**89**	**716**	**60.5**	**125**

TABLE VII. COST OF SOFTWARE QUALITY DATA FROM SOFTWARE PROFESSIONALS AND MANAGERS OF ONE MULTI-NATIONAL ORGANIZATION [30]

	Site A American Engineers (19)	Site A American Managers (5)	Site B European Engineers (13)	Site C European Engineers (14)	Site D European Engineers (9)
Cost of Performance	41%	44%	34%	31%	34%
Cost of Rework	30%	26%	23%	41%	34%
Cost of Appraisal	18%	14%	32%	21%	26%
Cost of Prevention	11%	16%	11%	8%	7%
Quality (Defects/ KLOC)	71	8	23	35	17

It is not rare to see, in immature organizations, software projects having 40 to 50 percent of rework. As an example, the author of this paper has collected data on the Cost of Software Quality (CoSQ) from professional engineers, managers, and graduate students working in industry in the professional software engineering master's program at the ÉTS engineering school of Montréal. As illustrated in Tables 7 and 8, the estimated cost of rework is about 30%. The industrial data were collected in two large multinational enterprises: one involved in the transportation sector and the other in the aerospace sector. The numbers in parenthesis indicate the number of people who have responded to the CoSQ survey.

TABLE VIII. COST OF SOFTWARE QUALITY DATA FROM PROFESSIONAL GRADUATE STUDENTS (ADAPTED FROM [30]

	Course A 2008 (8)	Course B 2008 (14)	Course C 2009 (11)	Course D 2010 (8)	Course E 2011 (15)	Course F 2012 (10)	Course G 2013 (14)
Cost of Performance	29%	43%	45%	45%	34%	40%	44%
Cost of Rework	28%	29%	30%	25%	32%	31%	25%
Cost of Appraisal	24%	18%	14%	20%	27%	20%	19%
Cost of Prevention	14%	10%	11%	10%	8%	9%	12%
Quality (Defects/ KLOC)	403	19	48	35	60	55	72

As illustrated in table 6 for this start-up project, about 8.9% (i.e. 89 hours/990.5 hours) of the total project effort has been spent in prevention tasks such as the installation of the server, the workstations and the software tools; and only 12.6% has been spent on rework (i.e. 125 hours /990.5 hours). This indicates that the use of appropriate standards, in this case for a start-up company, can guide all the phases of the development of a product such that the wasted effort (i.e. rework) is about the same as a more mature organization (i.e. about level 3 of CMM).

A large study was performed, in a large organization, to measure the cost of quality where 1100 software tasks were analysed on a software development project totalling 88,000 hours [30]. As illustrated in figure 5, the distribution of development costs in the various categories of software quality and implementation cost. At the time the cost of quality study was performed, this organization was at level 3 of the CMM maturity model.

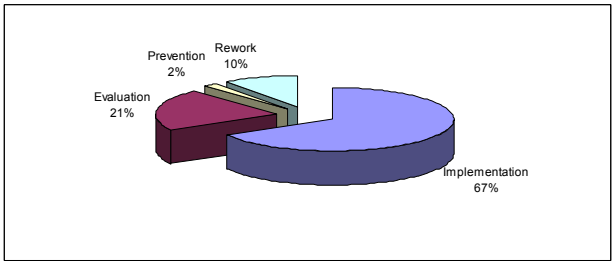

Figure 5. Distribution of effort in the 88,000-hour project

In most start-ups, the wasted effort, for a project similar to this one, would have added about 90 hours (i.e. 30% of 716 or 215 hours – 125 hours). This also implies, that for a net effort of about 6 hours per member per day (if we subtract from an 8-hour day interruptions (e.g. phone call), answering emails, discussions in corridors, etc.), the product would have been ready for delivery to a customer about 15 days, of 6 hours, later than with a project with only 12.6% of waste. This project has demonstrated that, by using ISO/IEC 29110, it was possible to properly plan the project and develop the software product using proven software practices documented in standards as well as not interfering with the creativity during the development of their web site. People who think that standards are a burden, an unnecessary overhead and a treat to creativity should look at this start-up project and revisit their results.

B. The Implementation in an Engineering Enterprise

A large engineering firm has implemented a program to define and implement project management processes for their small-scale and medium-scale projects. The firm already had a robust and proven process to manage their large-scale projects. Their projects are classified into three categories as illustrated in Table 9.

TABLE IX. CLASSIFICATION OF PROJECTS BY ENGINEERING FIRM [27]

	Small Project	Medium project	Large project
Duration	< 2 months	> 2 and < 8 months	> 8 months
Size of team	<= 4 people	> 4 and < 8 people	> 8 people
No. of Eng. specialties	1	>1	Many

involved			
Eng. fees	Between 5,000$ and 70,000$	Between 50,000$ and 350,000$	Over 350,000$

Pilot projects have been conducted to test the project management processes and associated support tools (e.g. templates, checklists). The pilot projects consisted of running three different projects where project managers implemented the process and the associated tools. Managers then evaluated the proposed processes, identified problems and potential improvements. The lessons learned sessions conducted at the end of the pilot projects have identified minor adjustments to the processes and tools. The engineering firm documented the business goals, as illustrated in Table 10, as well as the problems that one division of the company wished to solve.

TABLE X. DIVISION'S BUSINESS GOALS [27]

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 %.

There are several documents, or frameworks, describing recognized practices for project management, among which guides such as A Guide to the Project Management Body of Knowledge (PMBOK Guide) published by the Project Management Institute, maturity models such as the Capability Maturity Model Integration (CMMI) for Development of the Software Engineering Institute, and standards such as the new ISO/IEC 29110 series for very small entities.

A meeting with the improvement program project sponsors helped define a selection of criteria with a view to determining the most suitable project management framework for the company. The following criteria were selected:

- 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
- Framework documents are readily available

Before analysing the selected benchmarks, each criterion was weighted by its importance according to the project sponsors' perception. Table 11 describes the criterion used to evaluate the frameworks.

TABLE XI. CRITERIA USED TO EVALUATE THE FRAMEWORKS [27]

Criteria ID	Description of the criteria	Weight	Justification
1	Adapted for the management of small projects	High	The majority of projects are small projects. Using a complex method will need to be adapted to be effective. Using standards already adapted to small projects could reduce the effort required for the development of needed processes
2	Known to the management of the organization	Medium	Using a known framework should promote the commitment of management to solutions that will be developed.
3	Recognized by the company's customers	Low	Some customers have practical project management based on standards. The use of the similar frameworks could facilitate communication and monitoring of projects with customers
4	Tools to facilitate the use of standards are available	Medium	Using standards supported with tools could reduce the effort required for the development of processes
5	Ease of integration with existing organizational processes	High	Ease of integration with existing organizational processes
6	Accreditation/ Certification available	Low	Accreditation/ Certification available

7	Ease of access to documents	Low	The company has the monetary means to acquire the documents. The impact of this criterion is minimal.

ISO/IEC 29110 was the standard selected for the improvement project. Even if the company's division comprises more than 500 employees, a significant number of small-scale projects are carried out by separate teams focusing on one customer only. Since the ISO/IEC 29110 series applies to Very Small Entities (VSEs), i.e. enterprises, organizations, departments and projects of up to 25 people, this standard was very suitable for this company.

The project management practices used by the company's managers were assessed against the ISO standard's basic profile. The division used the project management process of the Entry profile of ISO/IEC 29110 to document their small-scale project management process and they used the project management process of the Basic profile to document their medium-scale project management process.

ISO has developed a methodology to assess and communicate the economic benefits of standards [28], which was used, by the engineering firm, to estimate the anticipated costs and benefits over a period of three years. The key objectives of the ISO methodology are to provide:

- A set of methods that measure the impact of standards on organizational value creation
- 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 approach used by the company comprises four steps:

1. Understanding the company's value chain
2. Analysing the value drivers
3. Identifying the impacts of standards
4. Assessing and consolidating results

The "value chain" is a concept can be used 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 company.

TABLE XII. TABLE OF VALUE DRIVERS [27]

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.	Quality of the design process
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) [1]
Project management capacity	Capacity to manage projects according to plans	Cost performance index (CPI)	Very important (completing projects is the company's core activity) [1]
Technical expertise	Ability to solve complex problems	Schedule performance index (SPI)	Important [2]
Geographic positioning	Geographic proximity of customers	Resource usage time (additional time)	Average importance [3]
Partnership	Capacity to initiate partnerships with other companies	Number of partnerships and recurring customers	Average importance [3]
Flexibility	Capacity to adapt to different customer needs	Number of services provided and type of service compared with competitors	Important [2]

After discussion with the members of the company's governance board, the elements shown in Table 12 were identified as the main value drivers for an engineering consulting firm.

The sponsors of this process definition project made the estimates. The improvement program project sponsors made an estimate of anticipated costs and benefits over a period of three years. Table 13 shows the results for the first three years.

TABLE XIII. COSTS AND BENEFITS ESTIMATIONS [27]

	Year 1	Year 2	Year 3	Total
Implement & maintain	59 600$	50 100$	50 100$	159 800$
Net Benefits	255 500$	265 000$	265 000$	785 500$

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

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. Project managers were trained in the new processes and support tools. Table 14 lists a sample of the projects that are or have been carried out by 4 project managers using the processes and tools developed during the improvement 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. 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.

TABLE XIV. PROJECT MOSTS CONDUCTED USING THE ISO/IEC 29110 PROCESSES AND TOOLS DEVELOPED DURING THE IMPROVEMENT PROJECT [27]

Budget	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

The engineering firm is planning to document and implement their systems engineering processes for the small-scale and medium scale projects using the Entry and Basic Profiles of the ISO/IEC 29110 systems engineering standard and guide once they get published by ISO.

IV. CONCLUSIONS AND FUTURE WORK

As ISO/IEC 29110 is an emerging standard there is much work yet to be completed. The main remaining work item is to finalize the development of the remaining two software profiles of the Generic Profile Group: (a) Intermediate - management of more than one project and (b) Advanced - business management and portfolio management practices. Once these software profiles are ready, WG24 will develop matching systems engineering profiles for VSEs.

For most enterprises, but in particular for VSEs, international certifications can enhance credibility, competitiveness and access to national and international markets. Brazil has developed an ISO/IEC 29110 certification process. An ISO/IEC 29110 auditor should be competent in auditing techniques, have expertise in ISO/IEC 29110 and have experience in software development. So far, ISO/IEC 29110 auditors from Belgium, Brazil, Canada, Mexico and Peru have been trained. For most VSEs with limited budget and time, such a certification should not be too expensive and long. The certification process has been successfully piloted in a few Brazilian VSEs. For each of these pilot audits, it took about 4 staff-days of work by the auditors. Similar to the existing set of software ISO/IEC 29110 TRs, the Management and Engineering Guide for systems engineering should also be made available at no cost by ISO. A set of DPs, to support the systems engineering standard, is freely available to VSEs on public web sites. These DPs used, as a reference, the INCOSE Handbook [29].

Since many VSEs developing systems are also involved in the development of critical systems, WG24 will conduct an analysis to determine if a set of systems/software standards for VSEs developing critical systems should be developed.

ADDITIONAL INFORMATION:

The following web site provides more information, as well as articles by WG24 members and deployment packages for software and systems engineering:

http://profs.logti.etsmtl.ca/claporte/English/VSE/index.html

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