

Systems Engineering International Standards and Support Tools for Very Small Enterprises

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Abstract. Very small entities are very important to the world-wide economy. The products they develop are often integrated into products made by larger enterprises. To address their needs, a set of ISO/IEC 29110 systems engineering standards and guides, such as a management and engineering guide, has been developed using ISO/IEC/IEEE 15288. The INCOSE systems engineering handbook is used as the main reference for the development of a set of systems engineering deployment packages. A deployment package is a set of artefacts designed to facilitate the implementation of a standard or a set of practices in a very small entity. Two pilot projects using the new ISO/IEC 29110 are presented. A cost and benefits analysis from implementing ISO/IEC 29110 in an engineering firm is also presented as well as the future ISO/IEC 29110 management and engineering guide for start-ups and for projects requiring no more than six person-months of work. Finally, the certification scheme is discussed as well as future developments.

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. In Europe, for instance, as illustrated in Table 1, over 92% of enterprises have fewer than nine employees.

There was a need to help these VSEs understand the benefits of international engineering standards, along with the concepts, processes and practices involved, and initiate their use.

Table 1: Size of enterprises in Europe (Moll 2013)

Type of enterprise	Number of employees	Annual turnover (EURO)	Number of enterprises (% of overall)	Number of enterprises
Micro-enterprises	1 - 9	≤ 2 million	92.2 %	19 968 000
Small enterprises	10 - 49	≤ 10 million	6.5 %	1 358 000
Medium enterprises	50 – 249	≤ 50 million	1.1 %	228 000
SMEs, total	87 100 000		99.8 %	21 544 000*
Large enterprises	> 250	> 50 million		
Large enterprises, Total	42 900 000		0.2 %	43 000

* Independent companies only, excluding legally independent companies that are part of large enterprises.

This paper presents a new project formed to facilitate access to, and utilization of, ISO/IEC JTC1/SC7 (International Organization for Standardization/International Electrotechnical Commission/Joint Technical Committee/Subcommittee 7) systems and software engineering standards by VSEs with up to 25 people. More specifically, we will describe the following:

- The ISO/IEC 29110 standards and guides for VSEs developing systems;
- The set of deployment packages for systems engineering;
- Two implementations of the ISO/IEC 29110;
- The ISO/IEC 29110 certification scheme;
- The future ISO/IEC 29110 management and engineering guide for start-ups and for projects requiring no more than six person-months of work.

Approach Used in Developing International Standards for VSEs

The approach used by Working Group 24 (WG24), mandated by ISO to develop standards and guides for VSEs, had to take into account, as a starting point, ISO requirements in terms of the definition of a standard. Indeed, since an international standard dedicated to the system life cycle processes was already available (i.e., ISO 15288) (ISO 2008a), WG24 used the concept of ISO profiles to develop systems engineering standards and guides for VSEs. From a practical point of view, a profile is a kind of matrix that distinguishes all elements that are taken from existing standards from those that are not.

Two papers about ISO standards and guides for VSEs developing software have been presented at the 2008 and 2012 INCOSE symposium (Laporte 2008, 2012). This presentation gave members of the INCOSE Board of Directors the idea of setting up a working group to help develop a set of standards and guides for systems engineering VSEs, similar to the ISO/IEC 29110 standards and guides developed for software VSEs.

A new INCOSE working group, the VSE working group,¹ was established in 2009 to apply systems engineering to product development for small and very small entities. The working

¹ <http://www.incose.org/practice/techactivities/wg/vsme/>

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group, created in April 2009 is composed of members of INCOSE and the *Association Française d'Ingénierie Système* (AFIS), mainly from Canada, France, Germany and the U.S.

At the first meeting of the INCOSE working group, the ISO project editor of standards and guides for VSEs developing software, who is also one of the co-authors of this paper, proposed an approach similar to that of WG24: conduct a survey, establish a set of requirements, create profiles (e.g., roadmaps), develop deployment packages to facilitate implementation of the standards and guides, and conduct pilot projects. The members of the working group agreed with this proposition. The initial goals of the working group were as follows (INCOSE 2009):

- Improve product development by using systems engineering methodology;
- Establish tailored practical guidance to apply to VSEs in the context of the prime contractor or subcontractor of commercial products;
- Contribute to standardization.

In November 2011, WG24 met in Ireland to launch the official development of the systems engineering International Standards (ISs) and Technical Reports (TRs) for VSEs. Delegates from Brazil, Canada, France, Japan, Thailand, the United States and INCOSE participated in the first meeting. A first draft was sent for a round of review within ISO in January 2012. More than 450 comments were submitted by seven countries. A new version was sent for a second round of review in December 2012, and fewer than 150 comments were submitted. The reader will find more details about the development of software standards and guides in a paper presented at the 2012 INCOSE Symposium in Italy (Laporte et al. 2012).

Profiles

The core characteristic of the entities targeted by ISO/IEC 29110 is size; however, there are other aspects and characteristics that may affect profile preparation or selection, such as business models (commercial, contracting, in-house development, etc.), situational factors (criticality, uncertainty environment, etc.) and risk. Creating a profile for each possible combination of values of these various dimensions would result in an unmanageable number of profiles. VSE profiles are therefore grouped in such a way as to be applicable to more than one category. Profile groups are a collection of profiles that are related either by composition of processes (i.e., activities, tasks), or by capability level, or both. A profile group provides a roadmap to VSEs.

Generic Profile Group

The generic profile group is a collection of four profiles (Entry, Basic, Intermediate, Advanced) and is applicable to VSEs that do not develop critical systems. VSEs targeted by the Entry profile are those working on small projects (e.g., at most six person-months of effort) and for start-ups. The Basic profile describes the development practices of a single application by a single project team with no special risk or situational factors. The Intermediate profile is targeted at VSEs developing multiple projects within the organization. The Advanced profile is targeted at VSEs wishing to sustain and grow as independent competitive businesses.

The ISO/IEC 29110 documents are as follows (adapted from ISO 2011a):

- ISO/IEC TR 29110-1 defines the business terms common to the VSE profile set of documents. It introduces processes, the concepts of life cycle and standardization, and the ISO/IEC 29110 series. It also introduces the characteristics and requirements of a VSE

and clarifies the rationale for VSE-specific profiles, documents, standards and guides (ISO 2011a).

- ISO/IEC 29110-2 introduces the concept of standardized profiles for VSEs and defines the terms common to the VSE profile set of documents. It establishes the logic behind the definition and application of standardized profiles. It specifies the elements common to all standardized profiles (structure, conformance, assessment) and introduces the taxonomy (catalogue) of ISO/IEC 29110 profiles (ISO 2011b).
- ISO/IEC TR 29110-3 defines the process assessment guidelines and compliance requirements needed to meet the purpose of the defined VSE profiles. It also contains information that can be useful to developers of assessment methods and assessment tools. It is written for people who are directly involved in the assessment process, e.g., the assessor and the sponsor, who need guidance on ensuring that the requirements for performing an assessment have been met (ISO 2011c).
- ISO/IEC 29110-4-1 and ISO/IEC 29110-4-6 provide the specification for all the profiles in the generic profile group. The generic profile group is applicable to VSEs that do not develop critical software or systems. ISO/IEC 29110-4-1 provides the specification for the software engineering profiles and ISO/IEC 29110-4-6 provides the specification for the systems engineering profiles. The profiles are based on subsets of appropriate standards elements. These specifications are targeted at authors/providers of guides, tools and other support material.
- ISO/IEC TR 29110-5-m-n and ISO/IEC 29110-6-m-n provide a management and engineering guide for the profile described in ISO/IEC 29110-4-1 for software engineering and ISO/IEC 29110-4-6 for systems engineering.

The ISO/IEC 29110 documents are targeted by audience as described in Table 2.

Table 2: ISO/IEC 29110 target audience (adapted from ISO 2014a)

ISO/IEC 29110	Title	Target audience
Part 1	Overview	VSEs and their customers, assessors, standards producers, tool vendors and methodology vendors.
Part 2	Framework and taxonomy	Standards producers, tool vendors and methodology vendors. Not intended for VSEs.
Part 3	Certification and Assessment guide	VSEs and their customers, assessors, accreditation bodies.
Part 4	Profile specifications	Standards producers, tool vendors and methodology vendors. Not intended for VSEs.
Part 5	Management and engineering guide	VSEs and their customers.

Parts 1, 2 and 3 are the same for both the software engineering (SW) and systems engineering (SE) domains, while parts 4 and 5 have different content for these two domains.

Finally, it is worth mentioning that, even though the processes are described according to a sequential/waterfall approach, the ISO/IEC 29110 series is not intended to dictate the use of any particular life cycle such as waterfall, iterative, incremental, evolutionary or agile.

Engineering and Management Guide for the Systems Engineering Basic Profile

The systems engineering Basic profile, as illustrated in figure 1, is composed of two processes: Project Management (PM) and System Definition and Realization (SR). An acquirer provides a SOW as an input to the PM process and receives a product as a result of SR process execution.

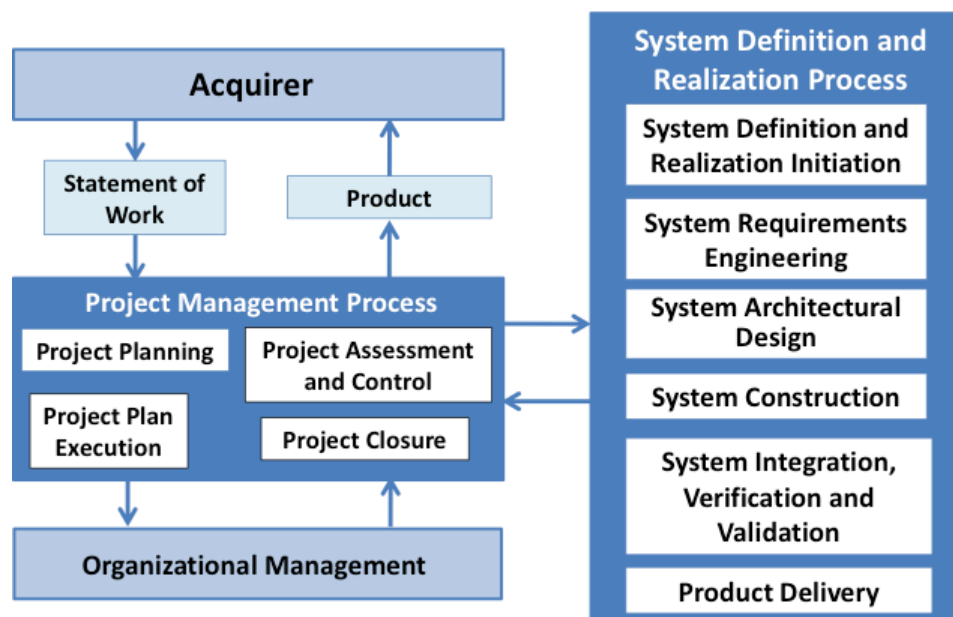


Figure 1. Processes of the systems engineering Basic Profile (Laporte 2014)

The ISO/IEC 29110 standards and guides for systems engineering are designed to work hand-in-hand with the ones for software engineering.

Project Management Process

As defined in ISO/IEC 29110, the purpose of the PM process is to establish the system engineering tasks and carry them out in a systematic way, which makes it easier to meet the project objectives with regard to expected quality, time and cost. The eight objectives of the PM process are as follows (ISO 2014a):

1. PM.O1. The project plan, SOW and commitments are reviewed and accepted by both the acquirer and the project manager. The tasks and resources necessary to complete the work are sized and estimated.
2. PM.O2. Progress is monitored against the project plan and recorded in the progress report. Actions to correct problems and deviations from the plan are taken when project

- targets are not achieved. Closure of the project is performed to get the acquirer's acceptance documented.
3. PM.O3. Change requests are addressed through their reception and analysis. Changes to system requirements are evaluated by the project team for cost, schedule, risks and technical impact.
 4. PM.O4. Review meetings with the work team, acquirer and suppliers are held. Agreements are written down and tracked.
 5. PM.O5. A risk management approach is developed. Risks are identified, analyzed, prioritized and monitored as they develop and during the project. Resources for managing the risks are determined.
 6. PM.O6. A product management strategy is developed. Items of product are identified, defined and baselined. Modifications to and releases of the items are controlled and made available to the acquirer and the work team. The storage, handling and delivery of the items are controlled.
 7. PM.O7. Quality assurance is performed to provide assurance that work products and processes comply with the project plan and system requirements specifications.
 8. PM.O8 A disposal management approach is developed to end the existence of a system entity.

To show the links between ISO/IEC/IEEE 15288 and the objectives of the PM process, Figure 2 shows the outcomes of the ISO15288 project planning process and measurement process used to develop Objective 1 of the PM process of ISO/IEC 29110.

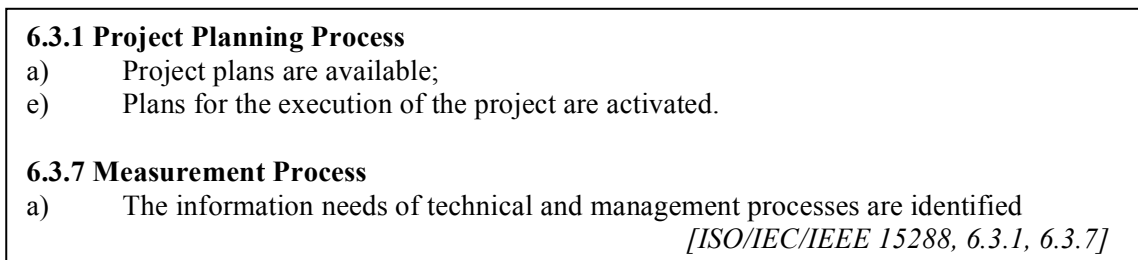


Figure 2. Links between ISO15288 outcomes and Objective 1 of the PM process (ISO 2014a)

Note that only a subset of the ISO/IEC/IEEE 15288 project planning and measurement processes has been selected for the Basic profile.

Modifications to the Software PM process of the ISO 29110 Software Engineering Basic Profile

Few modifications/additions were made to the software engineering Basic profile to develop the PM process for the SE Basic profile. The role of customer was replaced by the role of acquirer. Two tasks were added: *Define the system breakdown structure* and *Identify and document a disposal management approach*. Two tasks were modified: *Identify and document risks* was replaced by *Identify and document a risk management approach*; the *version control strategy* was replaced by *configuration management strategy*.

As illustrated in figure 3, the PM process uses the acquirer's Statement of Work (SOW) to establish the project plan. If there is no Statement of Work available from the customer, the

project manager, in collaboration with the members of the work team, has to set out a basis for developing one. In the PM project assessment and control activity, progress is compared against the project plan, and actions are taken to eliminate deviations or incorporate changes to the project plan. The PM project closure activity ensures delivery of the new or modified product produced by the SR process, and obtains the acquirer's acceptance to formalize the end of the project. A project repository is established to save the work products and to control versions during the project.

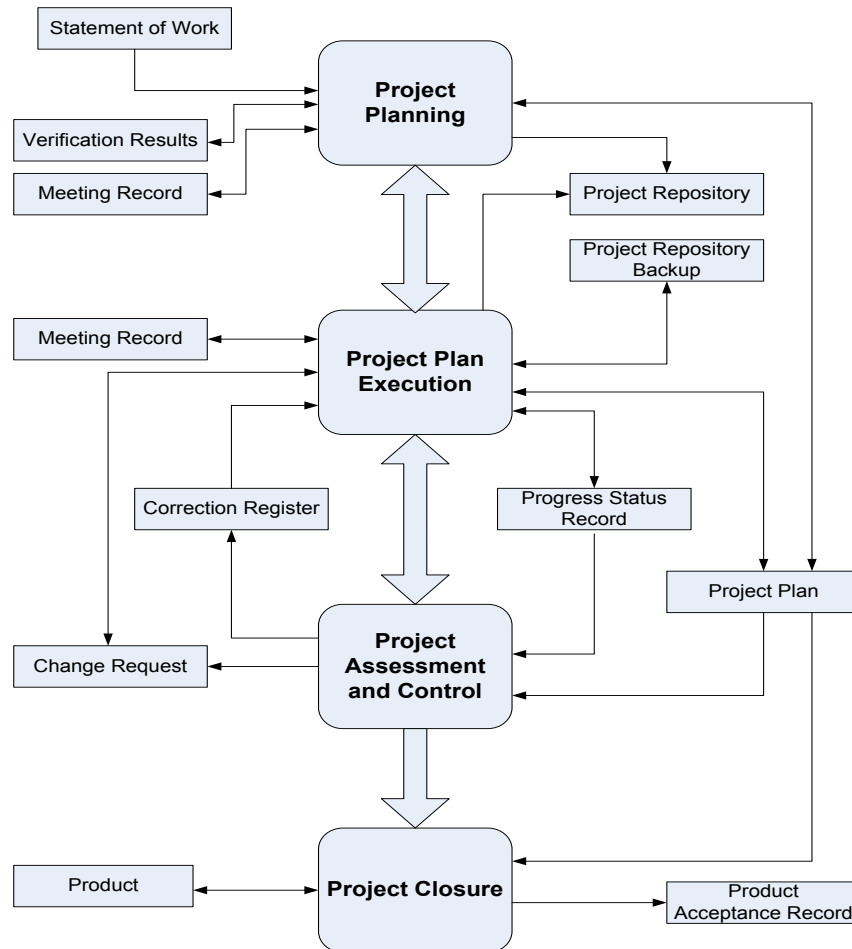


Figure 3. Project Management process for the SE Basic profile (ISO 2014a)

System Definition and Realization Process

The purpose of the System Definition and Realization (SR) process is the systematic performance of the analysis, design, construction, integration, verification and validation activities of new or modified systems according to the specified requirements. The seven objectives of the process are as follows (ISO 2014a):

1. SR.O1. Tasks of the activities are performed through the accomplishment of the current project plan.
2. SR.O2. System requirements are defined, analyzed for correctness and testability, approved by the acquirer, baselined and communicated.

3. SR.O3. The system architectural design is developed and baselined. It describes the system elements and their internal and external interfaces. Consistency and traceability to system requirements are established.
4. SR.O4. System elements defined by the design are produced or acquired. Acceptance tests are defined and performed to verify consistency with requirements and design. Traceability to the requirements and design is established.
5. SR.O5. System elements are integrated. Defects encountered during integration are corrected, and consistency and traceability to system architecture are established.
6. SR.O6. A system configuration, as agreed in the project plan (including the engineering artefacts), is integrated, baselined and stored at the project repository. Needs for changes to the product are detected, and related change requests are initiated.
7. SR.O7. Verification and validation of all required work products are performed using a defined criteria to achieve consistency among output and input products in each activity. Defects are identified, corrected and recorded in the verification/validation reports.

Modifications to the Software Implementation Process of the ISO 29110 Software Basic Profile

Some significant changes were made to the software implementation process for the systems engineering Basic profile: new system activities and tasks were added, irrelevant software activities were removed, and new system roles were defined. Also, new system documents were produced as the result of these additions/modifications.

The software Basic profile analyst role was replaced by the systems engineer role. The customer was replaced by the acquirer and the stakeholders. The programmer was replaced by the developer. Two new roles were also defined: the integration, verification and validation (IVV) engineer and the supplier.

With some exceptions, product descriptions are based on ISO/IEC/IEEE 15289 (ISO 2011f) information items. Nine product descriptions were added to the software Basic profile: data model, disposed system, integration report, IVV plan, IVV procedure, justification document, systems engineering management plan, system design document, system element, system element requirement specifications, and system maintenance document. The product descriptions were modified to align them with the system engineering context.

Figure 4 shows the flow of information between the activities in the SR process, including the most relevant work products and their relationships.

Deployment Packages to Support the Systems Engineering Basic Profile

The INCOSE VSE Working Group defined a set of guidelines explaining in more detail the processes defined in the Basic profile. These guidelines are freely accessible to VSEs on the Internet as a collection of Deployment Packages (DPs). A DP is a set of artefacts developed to facilitate the implementation of a set of practices for the selected framework in a VSE (Laporte 2009). Since the INCOSE handbook (INCOSE 2010) is a 'how to' document, it was used to develop the set of DPs.

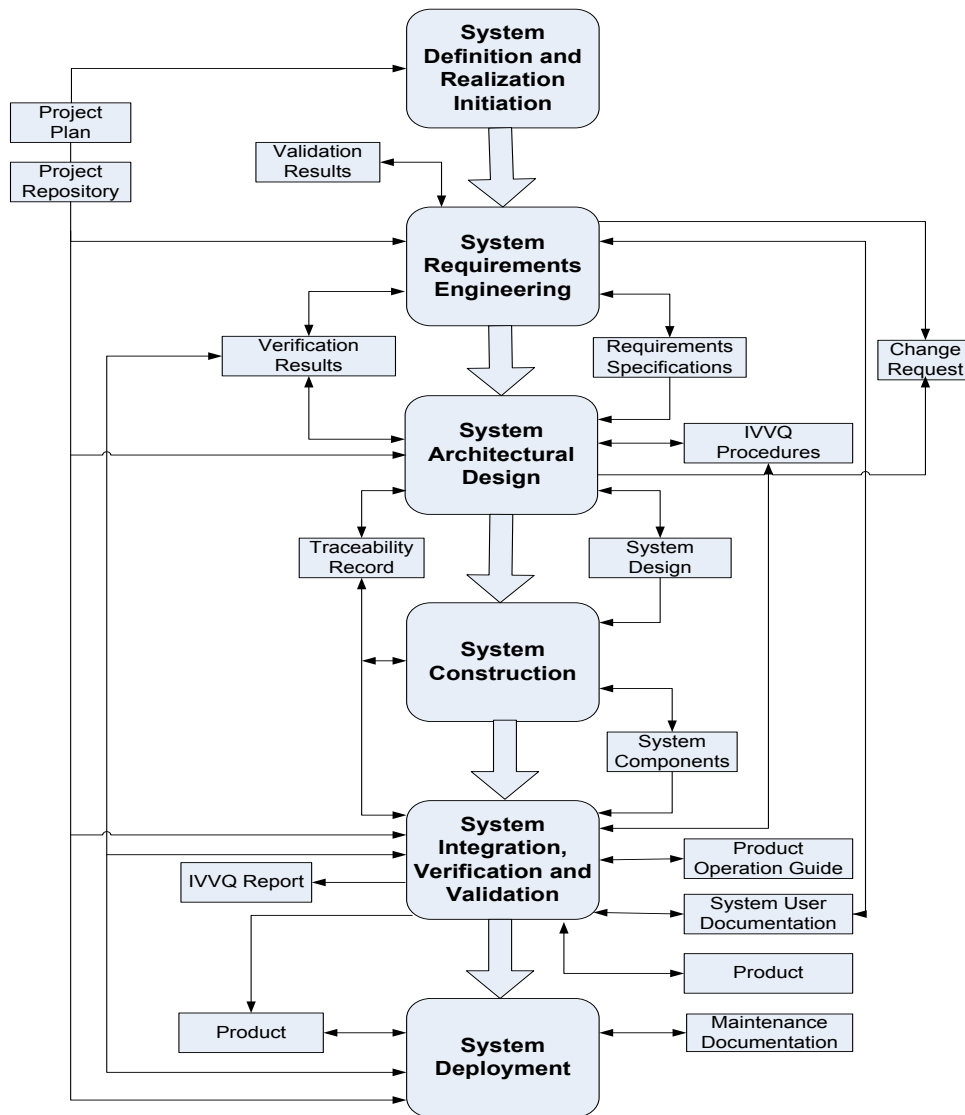


Figure 4. System Definition and Realization process for the SE Basic profile (ISO 2014a)

The components of a typical DP are: a process description (e.g., activities, tasks, steps, inputs, outputs and roles), templates, checklists, examples, reference and mapping to standards and models, list of tools, references, and an evaluation form. DPs are designed such that a VSE can implement its content without having to implement the complete Basic profile at the same time. The table of contents of a Deployment Package is illustrated in Table 3.

Table 3: Table of contents of an SE Deployment Package (adapted from Laporte et al. 2012)

1. Introduction
Purpose of this document
Key Definitions

2. Why this process is important
3. Overview of main tasks
3.1 Tasks
3.2 Roles and artefacts
3.3 Activity life cycle and examples of life cycles
Appendix A Templates
Appendix B Checklists
Appendix C Coverage Matrices (ISO 15288, ISO 9001, CMMI)
Appendix D Tools
Appendix E References
Appendix F Evaluation Form

Figure 5 illustrates the set of SE DPs for the Basic profile, which is available on the Internet² and on the INCOSE VSE page, at no cost to INCOSE members.

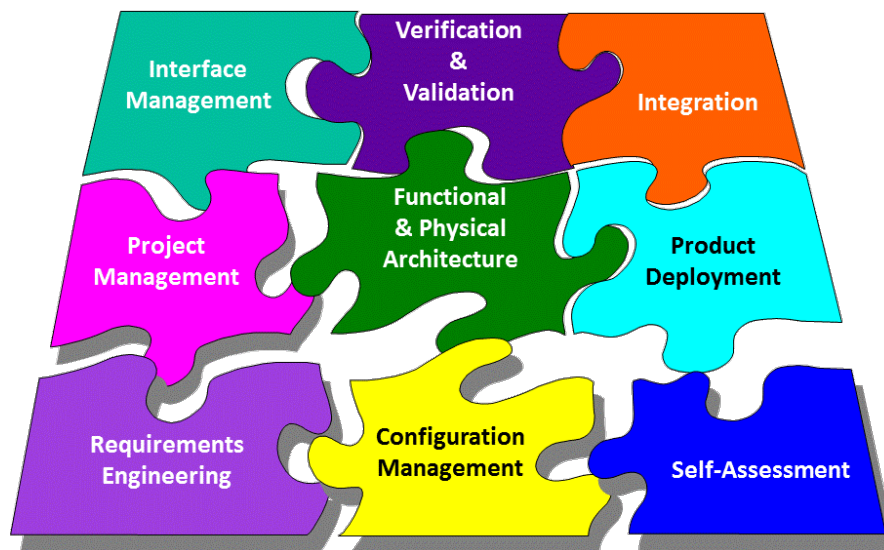


Figure 5. Proposed set of Deployment Packages for the SE Basic profile

A first commercial software solution using the Deployment Packages has been developed to facilitate the implementation of the Basic profile. The tool, 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:³

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

² <http://profs.etsmtl.ca/claporte/English/VSE/index.html> (Deployment Packages)

³ <http://nuumsolutions.com/?location=29110&lang=en>

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.

Pilot Projects Conducted in Systems Engineering Enterprises

So far, two systems engineering organizations have implemented ISO/IEC 29110. Here we briefly describe two applications of the management and engineering guide: one in a start-up VSE and one in a large engineering firm (Laporte 2014).

The first implementation project took place in a start-up VSE specialized in the integration of interactive communication systems-public address, visual information and media, vehicle wayside communications, networking and radio and safety systems such as CCTV, fire management, access control and intrusion detection, perimeter protection, emergency intercom in the mass transit industry (trains and buses). In this industry, customers often require a CMMI[®] maturity level (SEI 2010), such as a CMMI level 2 for sub-system suppliers. In 2012, the VSE was composed of just four professionals. It was felt that implementing the process areas of CMMI[®] was too demanding at that time. The company decided to implement the draft version of the ISO/IEC 29110 systems engineering Basic profile as a foundation for its development work. It was felt that, once the processes were documented and implemented in a few projects, the VSE could, if required, perform a gap analysis between the CMMI level 2 practices and the Basic profile and implement the practices needed for a level 2 assessment.

A large engineering firm implemented a program to define and implement project management processes for their small-scale and medium-scale projects. The firm already had a proven process for managing large-scale projects. Projects are classified into three categories, as illustrated in Table 4.

Table 4: Classification of projects by the engineering firm (Laporte et al. 2013b)

	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

The engineering firm documented the business objectives, as illustrated in Table 5, as well as the problems that one division of the company wished to solve.

Table 5: Division's business objectives (Laporte et al. 2013b)

Identification number	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 schedule overruns 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%.

The division used the project management process of the Entry profile of ISO/IEC 29110 to document its small-scale project management process and the project management process of the Basic profile to document its medium-scale project management process.

The "ISO Methodology to assess and communicate the economic benefits of standards" (ISO 2010) was used by the engineering firm to estimate the anticipated costs and benefits over a three-year period. The estimates were made by the sponsors of this process definition project. Figure 6 illustrates the company's value chain.

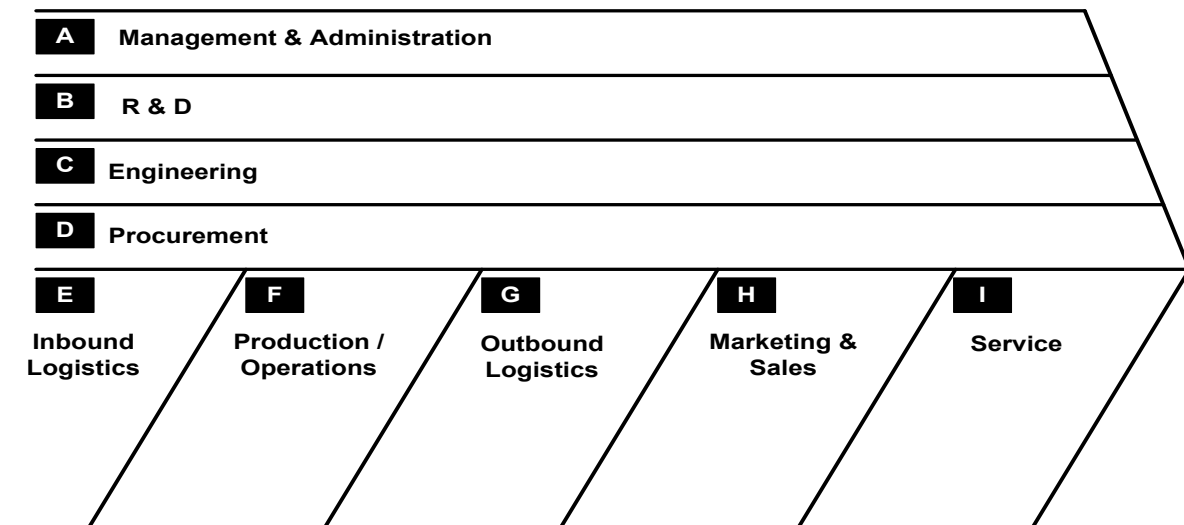


Figure 6. Value chain (ISO 2010)

An estimate of anticipated costs and benefits over a three-year period was made by the improvement program project sponsors. Table 6 shows the results of this cost/benefit estimation.

Table 6: Estimate of costs and benefits from implementing ISO/IEC 29110 (Laporte et al. 2013b)

	Year 1	Year 2	Year 3	Total
Cost to implement and maintain	\$59,600	\$50,100	50 100\$	159 800\$
Net benefit	255 500\$	265 000\$	265 000\$	785 500\$

The engineering firm is planning to document and implement its systems engineering processes for small-scale and medium-scale projects once the ISO/IEC 29110 systems engineering standard and guide for the Basic profile have been published by ISO.

ISO/IEC 29110 Certification of VSEs

For most enterprises, but in particular for VSEs, international certifications can enhance credibility, competitiveness and access to national and international markets. Brazil has led the development of an ISO/IEC 29110 certification process. An ISO/IEC 29110 auditor should be competent in auditing techniques, have expertise in ISO/IEC 29110 and have experience in system or software development. For VSEs, such a certification should not be too expensive or time-consuming. The certification process has been successfully piloted in a few Brazilian VSEs. For these pilots, it took about four person-days of work by the auditors. A first auditor course was conducted in English in Dublin in November 2013.

The certification scheme, described in ISO/IEC 29110-3-2 document (ISO 2013), is based on ISO Standards on conformity assessment. As illustrated in Figure 7, it is a four-stage certification process.

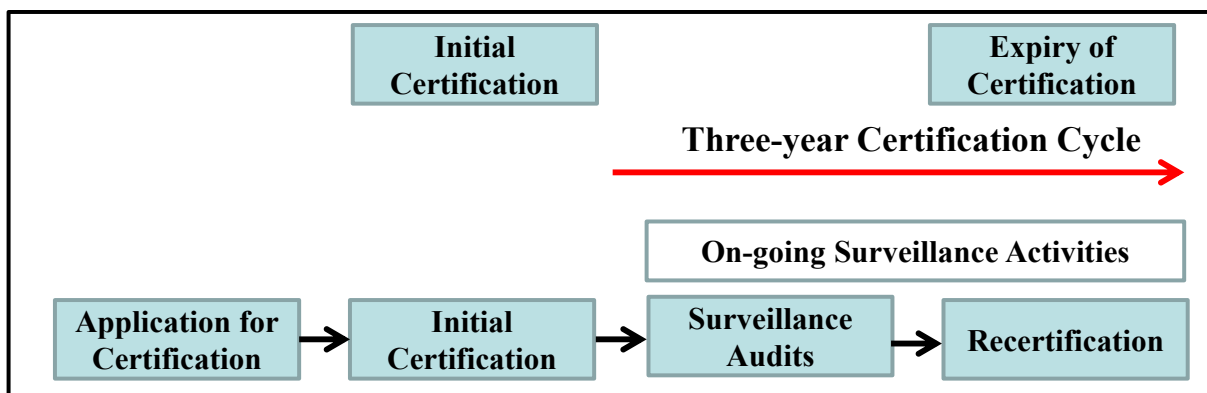


Figure 7. ISO/IEC 29110 four-stage certification process (adapted from ISO 2013b)

WG24 initially developed the management and engineering guide for systems engineering. This document is useful for VSEs wishing to implement the PM and SR processes. WG24 has started work on a Basic profile specifications document, i.e., ISO/IEC 29110-4-6. This document will be an international standard and will be required by the auditors when they perform an ISO/IEC 29110 audit.

Development of the Entry Profile for Systems Engineering

VSEs targeted by the Entry profile are those working on small projects (i.e., at most six person-months of effort) and start-up VSEs (ISO 2014b). The approach used by WG24 to develop this profile was to use, as the baseline, the Entry profile for software and the Basic profile for systems engineering, keeping in mind that both Entry profiles should be about the same size and should have the same structure. Also, if a VSE develops a system having a software component, it could use the SE Entry profile to guide the system development and the software Entry profile to guide the development of the software component.

A first draft of the objectives of the two processes in the SE Entry profile has been developed. The approach taken was as follows: the objectives of the PM and SR processes in the Basic profile were tailored on the basis of the objectives of the processes in the software Entry profile.

The objectives of the processes illustrated in the two tables below are documented using this notation: information added or modified to the SE Basic profile is shown underlined (in blue), while information deleted is shown in strike-out mode (in red). The proposed objectives of the PM process for the systems engineering Entry profile are illustrated in Table 7.

Table 7: Objectives of the PM process for the systems engineering Entry profile

Objective ID	Description
PM.01	The <i>Project Plan</i> , the <i>Statement of Work (SOW)</i> and commitments are reviewed and accepted by both the Acquirer and the Project Manager. The <i>Tasks</i> and <i>Resources</i> necessary to complete the work are sized and estimated.
PM.02	Progress of the project is monitored against the <i>Project Plan</i> and recorded in the <i>Progress Status Record</i>. 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 Acquirer acceptance documented in the <i>Acceptance Record</i> .
PM.03	<i>Change Requests</i> are addressed through their reception and analysis. Changes to system requirements are evaluated by the project team for cost, schedule, risks and technical impact.
PM.04	Review meetings with the Work Team and the Acquirer, suppliers are held. Agreements are registered and tracked
PM.05	A <i>Risk Management Approach</i> is developed. Risks are identified, analyzed, prioritized, and monitored as they develop and during the conduct of the project. Resources to manage the risks are determined.
PM.06	A <i>Product Management Strategy</i> is developed. Items of <i>Product</i> are identified, <u>and</u> defined <u>and baselined</u> . Modifications and releases of the items are controlled and made available to the Acquirer and Work Team. The storage, handling and delivery of the items are controlled.
PM.07	Quality Assurance is performed to provide assurance that work products and processes comply with the <i>Project Plan</i> and <i>System Requirements Specifications</i> .
PM.08	A <i>Disposal Management Approach</i> is developed to end the existence of a system entity.

The proposed objectives of the SR process for the systems engineering Entry profile are illustrated in Table 8.

Table 8. Objectives of the SR process for the systems engineering Entry profile

Objective ID	Description
SR.01	Tasks of the activities are performed through the accomplishment of the current <i>Project Plan</i> .
SR.02	System requirements and external interfaces are defined, analyzed for correctness and testability, approved by the Acquirer, baselined and communicated.
SR.03	The System architectural design is developed and baselined . It describes the <i>System elements</i> and internal and external interfaces of them. Consistency and traceability to system requirements is established.
SR.04	System elements defined by the design are produced or acquired. Acceptance tests are defined and performed to verify the consistency with requirements and the design. Traceability to the requirements and design are established.
SR.05	System elements are integrated. Defects encountered during integration are corrected and consistency and traceability to System Architecture are established.
SR.06	A System Configuration is prepared for delivery, as agreed in the Project Plan, and that includes the engineering artifacts is integrated, baselined and stored at the Project Repository. Needs for changes to the Product are detected and related change requests are initiated.
SR.07	Verification and Validation Tasks of the System all required work products are performed using a defined criteria to achieve consistency among output and input products in each activity. Defects are identified, and corrected; records are stored in the Verification/Validation Reports.

At the November 2013 WG24 meeting, delegates from the systems engineering sub-working group of ISO WG 24 reviewed the two tables and made modifications based on consensus. They then analyzed the PM and SR processes of the SE Basic profile and deleted/added/modified text in the activities, tasks, roles and products to produce a first draft of the SE management and engineering guide Entry profile (ISO 2014b). The document was sent for a first review cycle within ISO at the beginning of 2014. The comments received have been processed at the May 2014 meeting of WG24. A new version of the Entry profile will be sent for a second review cycle in August 2014. We expect this second review cycle to generate a few minor comments. These comments will be processed and the document should be ready for publication by ISO in 2015 and available at no cost from ISO.

Conclusion and Future Work

Industry recognizes the contribution of VSEs in terms of the valuable products and services they offer. A large majority of organizations worldwide have fewer than 25 people. Most system and software engineering standards are not easily applied in VSEs, where they are generally found difficult to understand and implement.

24th Annual International Council on Systems Engineering (INCOSE) International Symposium, Las Vega, July 1st 2014.

WG24 has developed a set of standards and guides to address the needs of VSEs developing system or software. WG24 has finalized in 2013 the development of the ISO/IEC 29110 systems engineering Basic profile. The INCOSE VSE WG produced a set of deployment packages to help implement the Basic profile. WG24 has started working on the Entry profile for systems engineering. Once a stable version of the Entry profile is available, the INCOSE VSE working group will be able to start the development of deployment packages to support it.

Once the ISO/IEC 29110 Intermediate and Advanced profiles for software are ready, work will start on the two corresponding systems engineering profiles for VSEs.

Since many VSEs around the world are developing components which are integrated in critical systems, WG24 and the INCOSE VSE WG will conduct an analysis to determine if a set of systems/software engineering standards for such VSEs 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>

References

(INCOSE 2009) INCOSE VSE Project Charter, 2009.

<https://connect.incose.org/tb/vsme/default.aspx>

(INCOSE 2011) Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities, INCOSE-TP-2003-002-03.2.2, International Council on Systems Engineering (INCOSE), 7670 Opportunity Rd, Suite 220, San Diego, CA 92111-2222, January 2011

(ISO 2008a) ISO/IEC/IEEE 15288:2008, Systems and software engineering - System life cycle processes, Geneva, Switzerland: International Organization for Standardization/International Electrotechnical Commission, 2008.

(ISO 2008b) ISO/IEC/IEEE 12207:2008, Systems and software engineering – Software life cycle processes. Geneva, Switzerland: International Organization for Standardization/International Electrotechnical Commission.

(ISO 2010) Economic benefits of standards: Implementation guide. Geneva, Switzerland: International Organization for Standardization, February 2010.

http://www.standardsinfo.net/info/benefits/benefits_sl.html

(ISO 2011a) ISO/IEC TR 29110-1:2011, Software Engineering - Lifecycle Profiles for Very Small Entities (VSEs) - Part 1: Overview. Geneva, Switzerland: International Organization for Standardization (ISO), 2011. Available at no cost from ISO at:

24th Annual International Council on Systems Engineering (INCOSE) International Symposium, Las Vega, July 1st 2014.

http://standards.iso.org/ittf/PubliclyAvailableStandards/c051150_ISO_IEC_TR_29110-1_2011.zip

(ISO 2011b) ISO/IEC 29110-2:2011, Software Engineering - Lifecycle Profiles for Very Small Entities (VSEs) - Part 2: Framework and Taxonomy, Geneva, Switzerland: International Organization for Standardization (ISO), 2011. Available from ISO at:

http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=51151

(ISO 2011c) ISO/IEC TR 29110-3:2011, Software Engineering - Lifecycle Profiles for Very Small Entities (VSEs) - Part 3: Assessment Guide. Geneva, Switzerland: International Organization for Standardization (ISO), 2011. Available at no cost at:

http://standards.iso.org/ittf/PubliclyAvailableStandards/c051152_ISO_IEC_TR_29110-3_2011.zip

(ISO 2011d) ISO/IEC 29110-4-1:2011, Software Engineering -- Lifecycle Profiles for Very Small Entities (VSEs) - Part 4-1: Profile specifications: Generic profile group. Geneva, Switzerland: International Organization for Standardization (ISO), 2011. Available from ISO at:

http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=51154

(ISO 2011e) ISO/IEC TR 29110-5-1-2:2011, Software Engineering - Lifecycle Profiles for Very Small Entities (VSEs) - Part 5-1-2: Management and engineering guide - Generic profile group: Basic profile, Geneva, Switzerland: International Organization for Standardization/International Electrotechnical Commission. Available at no cost from ISO at:

http://standards.iso.org/ittf/PubliclyAvailableStandards/c051153_ISO_IEC_TR_29110-5-1_2011.zip

(ISO 2011f) ISO/IEC/IEEE 15289:2011, Systems and software engineering - Content of systems and software life cycle process information products (Documentation), Geneva, Switzerland: International Organization for Standardization/International Electrotechnical Commission.

(ISO 2013) ISO/IEC PDTR 29110-3-2:2013 - Systems and Software Engineering - Systems and software engineering - Lifecycle profiles for Very Small Entities (VSEs) - Part 3-2: Conformity assessment guide, Geneva, Switzerland: International Organization for Standardization/International Electrotechnical Commission.

(ISO 2014a) ISO/IEC TR 29110-6-5-2:2014 - Systems and Software Engineering – Systems Engineering Lifecycle Profiles for Very Small Entities (VSEs) - Management and engineering guide: Generic profile group: Basic profile, Geneva, Switzerland: International Organization for Standardization/International Electrotechnical Commission. Available at no cost from ISO at:

<http://standards.iso.org/ittf/PubliclyAvailableStandards>

(ISO 2014b) ISO/IEC PDTR 29110-6-5-1:2014 - Systems and Software Engineering – Systems Engineering Lifecycle Profiles for Very Small Entities (VSEs) - Management and engineering guide: Generic profile group: Entry profile, Geneva, Switzerland: International Organization for Standardization/International Electrotechnical Commission.

24th Annual International Council on Systems Engineering (INCOSE) International Symposium, Las Vega, July 1st 2014.

(Laporte 2009) Laporte, C.Y., Contributions to Software Engineering and to the Development and Deployment of International Software Engineering Standards for Very Small Entities, Université de Bretagne Occidentale (France), October 28, 2009

(Laporte 2011) The Development and Experimentation of an International Standard for Very Small Entities Involved in Software Development, International Council on Systems Engineering (INCOSE) Workshop, January 29th 2011, Phoenix, Arizona.

(Laporte 2012) Laporte, Claude, Y, Fanmuy, Gauthier, Ptack, Ken, The Development of Systems Engineering International Standards and Support Tools for Very Small Enterprises, 22nd Annual International Symposium of the International Council on Systems Engineering, Rome, July 9-12, 2012.

(Laporte 2013a) Laporte, C.Y., Séguin, N., Villas Boas, G., Seizing the benefits of software and systems engineering standards, ISO Focus+, International Organization for Standardization, February 2013, pp 32-36.

http://www.iso.org/iso/home/news_index/iso_magazines/isofocusplus_index.htm

(Laporte 2013b) Laporte, C.Y., Chevalier, F., Maurice, J.-C., Improving Project Management for Small Projects, ISO Focus+, International Organization for Standardization, February 2013, pp 52-55. http://www.iso.org/iso/home/news_index/iso_magazines/isofocusplus_index.htm

(Laporte 2013c) Laporte, C.Y., O'Connor, R., Fanmuy, G., International Systems and Software Engineering Standards for Very Small Entities, *CrossTalk - The Journal of Defense Software Engineering*, May/June 2013, Vol. 26, No 3, pp 28-33.

(Laporte 2014) Laporte, C.Y, O'Connor, R., A Systems Process Lifecycle Standard for Very Small Entities: Development and Pilot Trials, 21st European Software Process Improvement Conference (Euro SPI 2014), Luxembourg, June 25-27, 2014.

(Moll 2013) Moll, R., Being prepared – A bird's eye view of SMEs and risk management, ISO Focus +, Geneva, Switzerland: International Organization for Standardization, February 2013.

(SEI 2010) Software Engineering Institute. (2010). CMMI for Development, Version 1.3, Pittsburgh, PA: Carnegie Mellon University. CMU/SEI-2010-TR-033.

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