

International Systems and Software Engineering Standards for Very Small Entities

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Abstract. Very Small Entities (VSEs) developing systems or software are very important to the military since the components they develop are often integrated into products made by larger organizations. Failure to deliver a quality product on time and within budget may threaten both customers and suppliers. One way to mitigate these risks is to put in place proven engineering practices. ISO has approved recently the publication of standards and technical reports, known as ISO/IEC 29110, to address the needs of VSEs.

Introduction

More than ever, integrators of military systems depend on their numerous suppliers to deliver sub-systems meeting evolving requirements correctly, predictably, rapidly, and cost effectively. A supply chain of a large system often has a pyramidal structure. If an undetected defect is left in a low level component, once this component is integrated into a higher level component, the defect may still be undetected. For example, as illustrated in Figure 1, a large manufacturer integrated into one of its products a component, with an undetected software error, which was produced by one of its lowest-level suppliers. This defective component resulted in a loss of millions of dollars by the manufacturer.

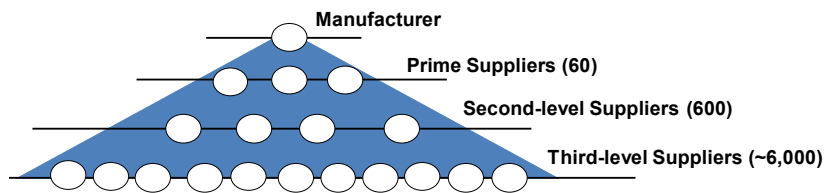


Figure 1: Example of the supply chain of a large manufacturer (adapted from [1])

The ability of organizations to compete, adapt, and survive depends increasingly on quality, productivity, cycle time and cost. Systems and software are getting bigger and more complex every year. As an example, a top of the line cars have up to 100 million lines of code, 80 processors and 5 bus systems [2].

Industry recognizes the value of VSEs, i.e. enterprises, organizations, projects or departments with up to 25 people [3], in contributing valuable products and services. There is a need to help these organizations understand the benefit of the concepts, processes and practices described in systems and software engineering standards, and to help them in their implementation. At every level of the supply chain, illustrated in figure 1, we find

VSEs since a system integrator as well as its prime suppliers have also very small projects.

Research shows that small and very small enterprises can find it difficult to relate to ISO standards to their business needs and to justify the application of the standards to their business practices [4]. Most of these enterprises do not have the expertise or can not afford the resources—in number of employees, cost, and time—or see a net benefit in establishing lifecycle processes. There is sometimes a disconnect between the short-term vision of an enterprise, looking at what will keep it in business for another six months or so, and the long-term or mid-term benefits of gradually improving the ways the enterprise can manage its development and maintenance processes. A primary reason cited by many small enterprises for this lack of adoption of systems or software engineering standards, is the perception that they have been developed by and for large companies and not with very small organizations in mind [5]. To date, VSEs have no or very limited ways to be recognized, by large organizations, as enterprises that produce quality products within budget and calendar in their domain and may therefore be cut off from some economic activities. Accordingly there was a need to help VSEs understand and use the concepts, processes and practices proposed in the ISO/IEC JTC1/SC7's¹ international engineering standards.

The recently published set of ISO/IEC 29110 international standards (IS) and technical reports (TR) are aimed at addressing these issues as well as the specific needs of VSEs. The engineering standards and guides developed by an ISO working group, Working Group 24 (WG24)², are targeted at VSEs which do not have experience or expertise in selecting, for a specific project, the appropriate processes from lifecycle standards such as ISO/IEC 12207 [6] or ISO/IEC 15288 [7], tailor them to the needs of a specific project.

In the next section, a high level summary of the approach used to develop the ISO/IEC 29110 standard and discuss some of its key concepts, including project management and software implementation processes. We will then present the initial support work on deployment assistance for VSE in using this standard and finish by discussing the planned future work.

The WG24 Approach to the Development of Standards for VSEs Developing Software

Since an international standard dedicated to the software lifecycle processes was already available, i.e. ISO/IEC 12207, WG24 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:

1. Develop a set of profiles for VSEs not involved in critical software development,
2. Select the ISO/IEC 12207 process subsets applicable to VSEs having up to 25 people,
3. Select the description of the products, to be produced by a project, using ISO/IEC 15289 standard [8],
4. Develop guidelines, checklists, templates, and examples to support the subsets selected.

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 [9]. 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 targeted to VSEs which want to sustain and grow as an independent 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.

Generic Profile Group			
Entry	Basic	Intermediate	Advanced

Table 1: Graduated profiles of the Generic profile group (adapted from [9])

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 ([9], [10], [11], [12], [13]) 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 been translated to French by Canada and to Spanish by Peru and adopted as a Peruvian national standard. The set of 5 documents has been translated to Portuguese by Brazil and adopted as a Brazilian 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 September 2012 in English [14] and in French [15].

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

ISO/IEC 29110	Title	Target audience
Part 1	Overview	VSEs, 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	Assessment guide	Assessors, customers and VSEs
Part 4	Profile specifications	Standards producers, tool vendors and methodology vendors. Not intended for VSEs.
Part 5	Management and engineering guide	VSEs and customers

Table 2: ISO/IEC 29110 target audience (adapted from [3])

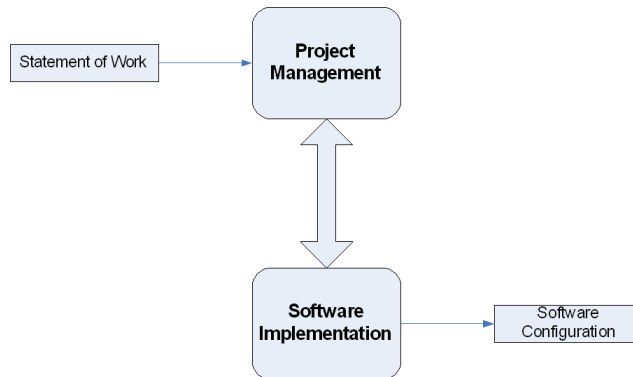


Figure 2: Basic profile process relationship [12]

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

Overview of the Project Management Process

The purpose of the Project Management process is to establish and carry out the tasks of the software implementation project in a systematic way, which allows compliance with the project's objectives in terms of expected quality, time, and costs [12]. The seven objectives of the PM process are listed in table 3.

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

Table 3: Objectives of the Project Management process of the Basic Profile [12]

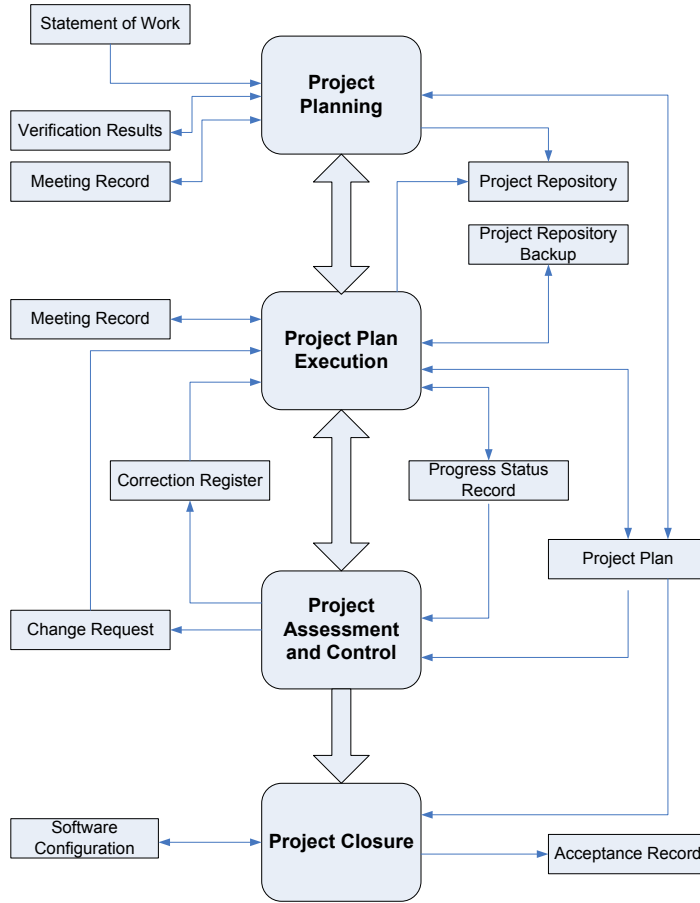


Figure 3: Project management process diagram for software [12]

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

Table 4: Example of 2 tasks of the Project Planning Activity [12]

SI.01. Tasks of the activities are performed through the accomplishment of the current Project Plan.
SI.02. Software requirements are defined, analyzed for correctness and testability, approved by the Customer, baselined and communicated.
SI.03. Software architectural and detailed design is developed and baselined. It describes the Software Components and internal and external interfaces of them. Consistency and traceability to software requirements are established.
SI.04. Software Components defined by the design are produced. Unit test are defined and performed to verify the consistency with requirements and the design. Traceability to the requirements and design are established.
SI.05. Software is produced performing integration of Software Components and verified using Test Cases and Test Procedures. Results are recorded at the Test Report. Defects are corrected and consistency and traceability to Software Design are established.
SI.06. A Software Configuration, that meets the Requirements Specification as agreed to with the Customer, which includes user, operation and maintenance documentations, is integrated, baselined and stored at the Project Repository. Needs for changes to the Software Configuration are detected and related change requests are initiated.
SI.07. Verification and Validation Tasks of all required work products are performed using the defined criteria to achieve consistency among output and input products in each activity. Defects are identified, and corrected; records are stored in the Verification/Validation Results.

Table 5: Objectives of the Software Implementation process of the Basic Profile [12]

Figure 3 illustrates the 4 activities of the project management process as well as their input and output products. Each activity is composed of tasks. The task description does not impose any technique or method to perform it.

For illustration purposes, two tasks of the Project Planning activity are listed in Table 4. On the left side of the table are listed the roles involved in a task. The project manager (PM) and the customer are involved in these 2 tasks.

The customer is involved, during the execution of the project, when he submits change requests, during project review meetings, for the validation and approval of the requirements specifications and for the acceptance of the deliverables.

Overview of the Software Implementation Process

The purpose of the (SI) process is to achieve systematic performance of the analysis, design, construction, integration, and test activities for new or modified software products according to the specified requirements [12]. The seven objectives of the SI process are listed in table 5.

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

Deployment Packages to Facilitate the Implementation of ISO/IEC 29110

As a novel approach taken to assist VSEs with the deployment of ISO/IEC 29110 and to provide guidance on the actual implementation of the Management and Engineering Guides in VSEs, a series of Deployment Packages (DPs) have been developed to define guidelines and explain in more detail the processes defined in the ISO/IEC 29110 profiles [16]. 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 mapping shows that a deployment package has explicit links to standards, such as ISO/IEC 12207, or models, such as the CMMI® for Development [17]. Hence by implementing a DP, a VSE can see its concrete step to achieve or demonstrate coverage [18].

DPs were designed such that a VSE can implement its content, without having to

implement the complete framework, i.e. of the management and engineering guide, at the same time. A set of nine DPs have been developed to date and are freely available from [19]. Figure 5 illustrates the set of DPs developed to support the Basic Profile.

The Development of Systems Engineering Standards and Guides for VSEs Developing Systems

In 2009, the International Council on Systems Engineering (INCOSE) Very Small and Micro Entities Working Group (VSME) was established to evaluate the possibility of developing a standard, using the Generic profile group scheme of the ISO/IEC 29110 series, based on ISO/IEC 15288, for organizations developing systems. The ISO/IEC 29110 standard is targeted at VSEs which do not have experience or expertise in tailoring ISO/IEC 15288 [20].

In November 2011, WG24 met in Ireland to launch the official development of the systems engineering 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. More than 450 comments have been submitted by seven countries. A second draft [21] was sent for a second round of review in December 2012. Less than 150 comments have been submitted and will be processed at the next WG meeting. A third and final cycle of review should start in July. The systems engineering Basic profile should be published by ISO either late 2013 or early 2014. A set of systems engineering DPs is also under development by systems engineers members of INCOSE to support the Basic Profile.

Conclusion and Future Work

A large majority of organizations worldwide have up to 25 people. The collection of ISO/IEC JTC1 SC7 standards was not easily applied in VSEs, which generally find engineering and management standards difficult to understand and implement. WG24 developed a series of ISO/IEC 29110 ISs and TRs for VSEs involved in the development of systems or software.

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

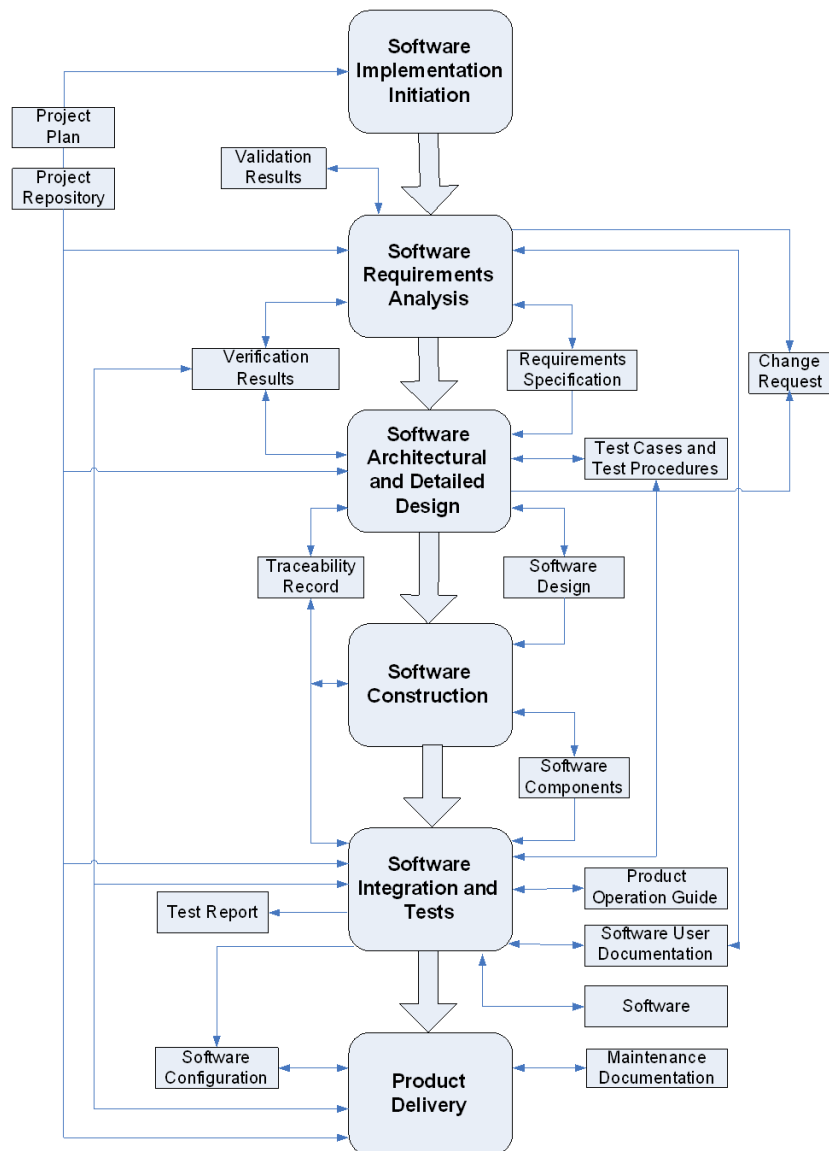


Figure 4: Software implementation process diagram [12]

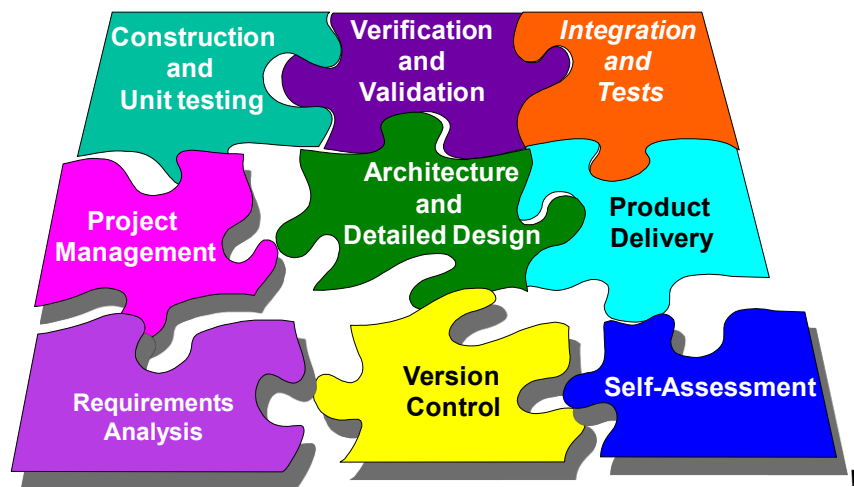


Figure 5. Deployment Packages to support the Software Basic Profile [18]

The publication by ISO, of the systems engineering Basic profile, is anticipated for either late 2013 or early 2014. 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.

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 led the development of an ISO/IEC 29110 certification process. An ISO/IEC 29110 auditor should be competent in auditing techniques, have expertise in ISO/IEC 29110 and have experience in software development. For VSEs, such a certification should not be too expensive and short. The certification process has been successfully piloted in a few VSEs. For these pilots, it took about 4 staff-days of work by the auditors.

The publication by ISO, of the systems engineering Basic profile, is anticipated for either late 2013 or early 2014. 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 future systems engineering standard, will be made freely available to VSEs on public Web sites. These DPs will use as a main reference the INCOSE Handbook [22].

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 about ISO/IEC 29110:

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

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NOTES

1. ISO/IEC JTC1/SC7 stands for International Organization for Standardization/International Electrotechnical Commission Joint Technical Committee 1/Sub Committee 7.
2. A previous Crosstalk article describes the establishment of Working Group 24 [7] [23].