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Applying Software Engineering Standards in Very Small Entities

From Startups to Grownups

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Standards and their associated technical documents, as sources of codified knowledge, could be considered a form of technology transfer. The correct selection and application of the appropriate standards should increase an organization's productivity and have a positive economic impact on that organization. In software engineering, a significant challenge is for the knowledge documented in standards to actually reach an organization and be applied for its benefit.

A large majority of organizations developing software are *very small entities* (VSEs), which have up to 25 people.¹ VSEs often have difficulty relating ISO/IEC standards to their business needs and justifying the application of those standards to their business practices.² Most VSEs either don't see the standards' net benefit, lack expertise, or can't afford the necessary employees, cost, and time. Reasons for not applying the standards include the perception that they are meant for larger organizations, are costly, require much documentation and bureaucracy, and don't clearly establish software processes.³ Also, without a documented development process or third-party certification, most VSEs have little or no way to be recognized as entities that produce quality systems or software products in their domain. So, they're cut off from some possible revenue sources.

To help meet the need for VSE-specific systems and software lifecycle profiles and guidelines, the International Organization for Standardization and the International Electrotechnical Commission jointly published the four-stage roadmap ISO/IEC 29110 series of standards and guides. These publications target VSEs, ranging from start-ups to grownups, with little or no experience or expertise in selecting the appropriate processes from systems or software engineering lifecycle standards (such as ISO/IEC/IEEE 12207) and tailoring them to a project's needs.

Here, we give an overview of ISO/IEC 29110, some examples of VSEs that have implemented it, and those implementations' results.

ISO/IEC 29110

ISO/IEC 29110 defines a VSE as “an enterprise, an organization, a department, or a project having up to 25 people.”¹ Because most large organizations are structured to make them manageable (for example, by project or department), VSEs are present at all stages of a product manufacturing chain.

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The core of ISO/IEC 29110 is a management and engineering guide (ISO/IEC 29110-5) focusing on project management and software implementation (see Figure 1). A customer provides a *statement of work* as an input to the project management process. Then, the VSE's management accepts or declines the project. If management accepts the project, the planning activity of the project management process will initiate the project. The project is executed until the customer receives, as a result of the software implementation process, the product described in the statement of work.

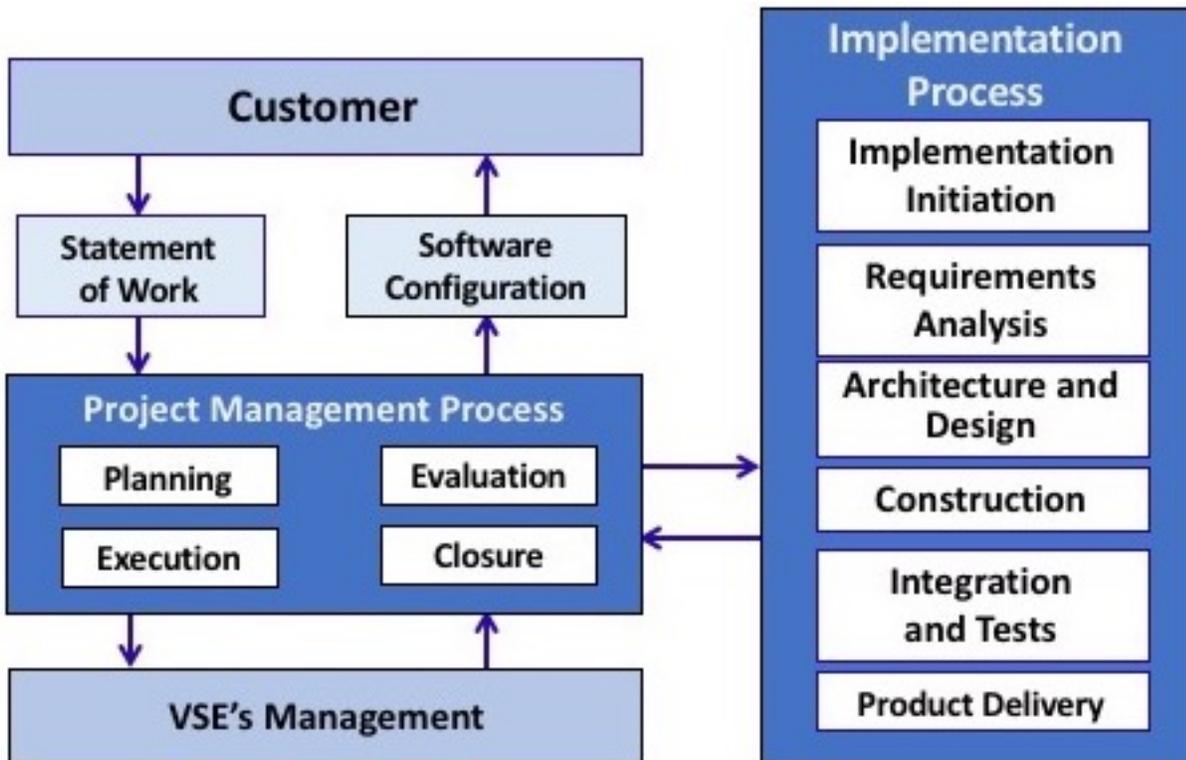


Figure 1. Processes and activities of the ISO/IEC 29110 software engineering Basic Profile. ISO/IEC 29110 targets very small enterprises with little or no experience or expertise in selecting the appropriate processes from lifecycle standards and tailoring them to a project's needs.

To further illustrate process detail, Table 1 presents the validation tasks in the requirements analysis activity of the software implementation (SI) process. The table is based on the entry in the ISO/IEC 29110 management and engineering guide. CUS stands for customer; AN stands for analyst.

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Table 1. An example of one task of the requirements analysis activity.¹

Roles	Task list	Input Work Product	Output Work Products
CUS AN	<p>SI.2.4 Validate and obtain approval of the <i>Requirements Specification</i></p> <p>Validate that <i>Requirements Specification</i> satisfies needs and agreed upon expectations, including the user interface usability.</p> <p>The results found are documented in a <i>Validation Results</i> and corrections are made until the document is approved by the CUS.</p>	* <i>Requirements Specification [verified]</i>	<p>*<i>Requirements Specification [validated]</i></p> <p>*<i>Validation Results</i></p>

Learn more about ISO/IEC 29110 at profs.logti.etsmtl.ca/claporte/English/VSE/index.html. The ISO/IEC 29110 standards and guides are available for free at standards.iso.org/ittf/PubliclyAvailableStandards/index.html.

Some ISO/IEC 29110 Implementations

Worldwide, hundreds of VSEs have implemented ISO/IEC 29110. For instance, in Thailand, an early adopter of ISO/IEC 29110, more than 350 public and private organizations have achieved the ISO/IEC 29110 Basic Profile certification.⁴ In addition, 33 other VSEs are certified in other states of Mexico. In the state of Zacatecas in Mexico, industry, academia, and government came together in 2017 to promote ISO/IEC 29110. In Zacatecas, approximately four Mexican VSEs and four software development centers of academic institutions are certified for the Basic Profile. In addition, 33 other VSEs are certified in other states of Mexico.⁵ Researchers in Canada have led numerous field trials with early-stage adopters of ISO/IEC 29110.⁶

Table 2 provides an overview of 11 implementations representing a spectrum of VSEs that have harnessed the standard's benefits.

Table 2. ISO/IEC 29110 implementations in very small entities (VSEs)

VSE	Situation	Results
A Peruvian IT start-up	<ul style="list-style-type: none"> The company, established in 2012, used agile methods and practices (for example, Scrum, test-driven development, and continuous integration). It adapted ISO/IEC 29110 to these agile practices. The ISO/IEC 29110 processes were executed in a project 	<ul style="list-style-type: none"> The company grew to 18 employees. Only 18 percent of the 900-hour project involved rework. In 2014, this company became the first Peruvian VSE to obtain ISO/IEC 29110 certification, which greatly facilitated access to new clients and larger projects. The process involved an audit costing

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	with the second-largest insurance company in Peru.	US\$1,500 and a surveillance audit costing US\$1,200 (excluding the auditor's travel expenses).
An IT start-up with locations in Canada and Tunisia	<ul style="list-style-type: none"> This company, established in 2013, developed web solutions and mobile apps. The company implemented the ISO/IEC 29110 Basic Profile. 	<ul style="list-style-type: none"> The company grew to 20 employees in 2016 (18 employees in Tunisia). A successful third-party audit was conducted in 2016. The company's military customers require CMMI Level 2. The Basic Profile serves as a foundation to implement CMMI for Development practices. The company is participating in a Smart City project in Tunisia using ISO/IEC 29110.
A development team at a Canadian IT start-up	<ul style="list-style-type: none"> The team comprised two developers. The company's web application let users simply collaborate on planning trips and share their trips with others. The total effort for this project was nearly 1,000 hours. The team used the Basic Profile. 	<ul style="list-style-type: none"> The team was able to develop a high-quality application. Only 12.6 percent of the effort involved rework. This indicates that using the appropriate standards can guide the development of a product such that the wasted effort—that is, rework—is about the same as in more mature organizations.
A VSE in Zacatecas, Mexico	<ul style="list-style-type: none"> The company developed hardware and software solutions. It had 12 employees, including highly trained specialists in electronic development and in hardware and software development. The project used for ISO 29110 certification was the development of a system to control access to the company offices. 	<ul style="list-style-type: none"> The software development process gained defined steps, work products, and roles. The project plan information was reinforced. Project monitoring and control were reinforced. The software and tools used in a project became controllable. Project versioning and software delivery improved.
A VSE in Zacatecas	<ul style="list-style-type: none"> The company, which had seven employees, used technologies and platforms oriented to web and mobile applications. It created software that both it and its customers used. The project used for ISO/IEC 29110 certification was the development of a web system that quotes and compares car insurance rates. 	<ul style="list-style-type: none"> Software development improved. Communication with the customer improved. Change requests improved. Documented forms were implemented as part of the development cycle. Verification improved. Validation and approval of documents improved. Test documentation improved.
A VSE in Zacatecas	<ul style="list-style-type: none"> The company, which had three employees, provided IT services to other organizations. The project used for ISO/IEC 29110 certification was the development of software to manage medical 	<ul style="list-style-type: none"> Project monitoring and control improved. Use of the delivery instructions improved communication with customers. Risk management improved.

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	consultations.	
A VSE in Zacatecas	<ul style="list-style-type: none"> The company, which had four employees, offered hardware, firmware, and software solutions. The project used for ISO/IEC 29110 certification was the redesign of an engine control system. 	<ul style="list-style-type: none"> Software development used a standardized methodology. Costs (mainly unforeseen costs) and development time decreased. Certification is a differentiator between companies in the same sector.
The software developers at a power train manufacturer	<ul style="list-style-type: none"> The company had 140 employees, of which 14 were developers. The developers worked on embedded software to control power trains. New projects started using ISO/IEC 29110-based processes. 	<ul style="list-style-type: none"> An analysis of the Basic Profile and ISO 26262, which covers the functional safety of electrical and electronic systems for road vehicles, demonstrated that the Basic Profile could be a good foundation for ISO 26262.
A software team at a large public-utility	<ul style="list-style-type: none"> The IT division had 1,950 employees supporting 2,100 applications. The IT division implemented 12 process areas of CMMI Levels 2 and 3. The software team comprised 11 people who developed web apps. The company implemented the ISO/IEC 29110 Basic Profile, adapted for Scrum. 	<ul style="list-style-type: none"> For the 1,511-hour project, approximately 8.5 percent of the effort involved prevention tasks, and only 9.6 percent involved rework. The team set an example for future small IT projects at the public utility.
Project teams in a large engineering company's Transmission & Distribution of Electricity division	<ul style="list-style-type: none"> The company was 10 years old, with 400 employees across 10 offices. The division was already using a robust project management (PM) process for its large-scale projects. Small projects lasted less than two months, with a team of up to four people and engineering fees between Can\$5,000 and Can\$70,000. The division defined organizational objectives, such as a 10 percent reduction of corrective work during quality control. The division used the ISO/IEC 29110 Entry Profile to develop the PM process for small projects and the Basic Profile to develop the PM process for medium projects. (More than 95 percent of the projects were small or medium.) 	<ul style="list-style-type: none"> The estimated costs and benefits over three years included better staff training, additional costs for staff, higher-quality deliverables, better management of quality, and more effective internal standardization. (The estimated implementation and maintenance costs were Can\$159,800; the estimated net benefits were Can\$785,500.) The division will use the systems-engineering Entry Profile and Basic Profile to redefine and improve its engineering process. This process will address the activities from engineering requirements identification to final product delivery.
A software team in a large financial institution's IT division	<ul style="list-style-type: none"> The IT division had 3,650 employees supporting 1,200 applications. The software team comprised six people who developed tools for traders. The team implemented an ISO/IEC 29110 Basic agile process with Scrum. 	<ul style="list-style-type: none"> The number and impact of problems after deployment of the ISO/IEC 29110 agile process decreased considerably.

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Some ISO/IEC 29110 documents, such as the management and engineering guide, are freely available. They've been translated into Czech, French, Portuguese, and Spanish and adopted as national standards by several countries. So, the number of implementations should rapidly increase. The guide's availability and accessibility have also greatly helped the standards' adoption by academia. More than 18 countries are teaching ISO/IEC 29110 at the undergraduate and graduate levels in software quality assurance or process improvement courses or as part of a capstone project.⁷

At the request of systems engineers who develop systems that typically comprise hardware and software components, a systems engineering ISO/IEC 29110 four-stage roadmap, similar to the software engineering roadmap, is also under development.

We're using our study of VSEs to build an experience factory that will help them start software process improvement (SPI) initiatives and promote their chosen SPI practices.⁸ As part of a community, they'll be able to share experiences, practices, and knowledge.

We live in an age in which software engineering knowledge and technology should be transferred from researchers to practitioners to reduce the gap between what the industry needs for VSEs and what researchers are producing. Interaction and collaboration between government, industry, and academia have benefited hundreds of early adopters of ISO/IEC 29110. The next step is to accelerate transfer of the knowledge documented in ISO/IEC 29110 to thousands of VSEs worldwide that develop systems or software products.

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