

## VSE 101 – Who, What, When, Where, Why, How

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**Abstract.** International standards capture proven engineering practices for systems engineering and software engineering development. The perception by very small entities (VSEs) is that these standards are developed and targeted for use by large enterprises. However, governments and industry alike recognizes that VSEs, consisting of 25 staff members or less, constitute a majority of the systems and software developers throughout the world.

During a world-wide survey of many different domain VSEs, it was verified that existing ISO standards were “too complicated” for use by VSEs. In 2005, the first meeting of ISO/IEC JTC1 SC7 Working Group (WG) 24 was held. This ISO WG is mandated to develop standards and guides for VSE use, thus the work on the ISO/IEC 29110 series began.

The paper will address how the ISO/IEC 29110 series and the INCOSE VSE WG deployment packages (DPs) work collaboratively to help VSEs incorporate systems engineering concepts within their entities. The use of these systems engineering concepts can provide VSEs the opportunity to successfully participate and grow in the global market environment.

### Introduction

This paper uses the structure and concepts of journalism’s “5 W’s (and How)” to address the VSE business challenges and how the ISO 29110 series can help them incorporate systems engineering concepts and practices within their product development. It has been shown that these same questions are essential to the survival and prosperity in the business environment, as they are in journalism. Systems, in the context of ISO 29110 series, are typically composed of hardware and software components. The paper will answer these “5 plus 1” questions, some of them multiple times in different ways, based on several OECD reports, coupled with ISO and INCOSE independent survey results.

### Who: Users and potential users?

We need to understand our community, the users, and potential users of our products. The better we know who they are, the better we can deliver value for them, and the better we can serve their businesses. In this section, we will address who is a very small entity (VSE). There are several different definitions for a VSE, but for this paper, the definition that is defined by the ISO/IEC 29110 series (ISO 29110 hereon) will be used. The ISO 29110 definition is: Very Small Entity – an enterprise, organization, department or project having up to 25 people.

According to the “*Small Business the Heart of the Global Economy Entrepreneurship at a Glance 2015*” Organisation for Economic Co-operation and Development (OECD) Report, governments realize why VSEs matter: because they are the sources of new jobs. VSEs are important for their contribution to employment, innovation, economic growth, and diversity. Creating new jobs and

in particular “good jobs”, means jobs in high productivity sectors offering decent working conditions. This is one of the major challenges for low and middle income countries. According to the 2013 World Development Report, 600 million jobs are needed worldwide over the next 15 years to keep employment rates at their current level (World Bank, 2012). Governments, non-governmental organizations, and donors spend large amounts of money for targeted programs and broader policies to enhance the creation of new firms and employment opportunities. Because most employment in low and middle income countries is in the VSE arena, often these firms are targeted by such interventions. Typical interventions include the provision of finance and financial services, entrepreneurship training, business support services, wage subsidies, and measures that transform the business environment. Despite these efforts, not much is known about which of these interventions are really effective, or more importantly, under which conditions particular interventions work. This is a topic of considerable relevance, principally owing to the observed growth effects of cross-border venturing, and the demonstrated capacity of VSEs to drive economic development at national, regional, and global levels. Limited firm resources and international contacts, as well as lack of requisite managerial knowledge about internationalization, have remained critical constraints to VSE internationalization.

The mission of the OECD is to promote policies that will improve the economic and social well-being of people around the world. The *2nd OECD CONFERENCE OF MINISTERS RESPONSIBLE FOR SMALL AND MEDIUM-SIZED ENTERPRISES (SMEs) PROMOTING ENTREPRENEURSHIP AND INNOVATIVE SMEs IN a GLOBAL ECONOMY: TOWARDS A MORE RESPONSIBLE AND INCLUSIVE GLOBALISATION (2004)* stated that SMEs play a key role in transitioning and developing countries. The *OECD Entrepreneurship at a Glance 2015 Report* states that over 90% of businesses in the world (outside the agricultural sector) are smaller than 20 employees. It also states “...number of manufacturing firms across all size classes declined between 2008 and 2012 in most OECD countries. In those countries in which the number of small and medium-sized enterprises increased, this was accompanied by falls in the number of large enterprises, suggesting that some of the increase in VSEs may have occurred as a result of lay-offs in (previously) large firms...” These firms constitute a major source of employment and generate significant domestic and export earnings. As such, VSE development has emerged as a key instrument in poverty reduction efforts worldwide.

There are VSEs in all organizations, large, medium, and small. The VSE can be the designer of a product, manufacturer of an end item, the prime contractor, a supplier at any level of production, or a producer for the final product realization (Laporte et al. 2012). Figure 1 shows the relationships of a VSE for the product realization process. Any one of the nodes can be a VSE at any level of the supply chain process.

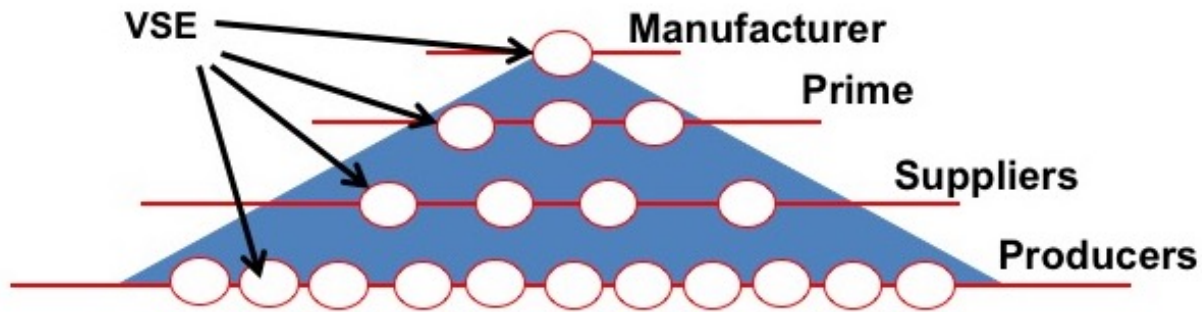


Figure 1. VSE Relationships (Laporte et al. 2012)

### What: Makes us different?

In this section we will address some of the issues that makes a VSE different from a large business. VSEs around the world are creating valuable products and services for the consumer. Many VSEs develop and maintain system and software components used in systems, either as independent products or incorporated into larger systems. The recognition of VSEs as suppliers of high quality products is required.

OECD reports state there is worldwide consensus that high rates of economic growth contribute to social development and poverty reduction. At the same time, there is growing recognition that poverty reducing growth depends on the quality of the growth, its composition, distribution, and sustainability. Over the years, OECD studies have also shown that between 30 and 60 per cent of start-up VSEs can be characterized as *innovative*, of which some 10 per cent of these are *technology-based*. Innovative VSEs tend to be *market-driven* rather than research-driven, and are quicker in responding to new opportunities than larger firms. VSEs play a key role in developing new markets and programs for improving the incorporation and diffusion of technology throughout all industries.

Average employment in start-up VSEs typically range between two and three persons to an average of more than seven persons. Start-up rates have been on an upward trend in recent years, while bankruptcies have been trending downwards in most countries. VSEs typically account for more than 95% of all firms outside the agriculture sector. They constitute a major source of employment and generate significant domestic and international earnings in the OECD. Improved VSE competitiveness obviously contributes to economic and social development and poverty reduction worldwide.

The OECD's assessments of growth converge on the opinion that a country's rate of growth is substantially determined by 1) their ability to integrate with the global economy through trade and investment; 2) their capacity to maintain sustainable government finances and sound money; and 3) their ability to put in place an institutional environment in which contracts can be enforced and property rights can be established. Of note is that *Regulatory burdens* remain a major obstacle for VSEs as they tend to be poorly equipped to deal with the problems arising from regulations. Access to information about regulations should be made available to VSEs at minimum cost. Policy makers must ensure that the compliance procedures associated with research and development and new technologies, are not unnecessarily costly, complex or lengthy.

More than half of start-ups fail within the first five years, with rates of surviving firms varying from less than one in five firms in Lithuania to about two-thirds in Sweden. Despite this relatively high probability of failure, it has been shown that one-year-old firms in most countries generate more employment than new firms and two-year-old firms do.

To accommodate VSEs longevity and growth, their financial stability needs to be considered. To support this, Governments need to address: uncertainties in the tax, regulatory, and macroeconomic environment; make sure that business framework conditions do not impact unfavorably on the risk/reward ratio; and encourage the mobility of human resources and the markets for specialized services. Although these are important considerations for the entire economy, such actions will produce strong benefits to VSEs.

The ISO 29110 series work and the INCOSE VSE WG DP work brings the international standards and systems engineering organizations together in a collaborative effort. The objective is to provide useful process documentation for the broad VSE segment use on how to organize and structure a project using the ISO 29110 series. VSE and medium sized entities are estimated to drive over 98% of the global economy.

***What? The best standards help people understand the importance and impact of the use of standards, and what it means to them and their product. The successful standards use those measurable results to answer “so what?” for customers. You need to show customers the importance, impact, and value of using standards that affects their productivity, lives, and profits.***

It has been shown that international standards capture proven engineering practices for systems engineering and software engineering development. The use of these standards can help organizations in their product realization efforts by adding a structured approach. This structured approach can be enhanced by the standardization of their processes, supporting tools, and supporting technologies, thereby improving the quality of the systems and software products overall.

Research shows that small and very small enterprises can find it difficult to relate ISO standards to their business needs and to justify the application of the standards to their business practices. Most of these enterprises do not have the expertise or cannot afford the resources - in number of employees, cost, and time - or see a net benefit in establishing lifecycle processes.

The INCOSE VSE WG started as a collaborative effort between INCOSE, AFIS, and ISO SC7 WG24 to support VSEs worldwide. This effort brings the international standards organization and the international systems engineering organization together in a collaborative effort. The objective is to provide useful process documentation and tools for the broad VSE segment, estimated to drive over 98% of the global economy.

The use of the ISO 29110 series for software project management processes for small scale engineering projects has been piloted by a large engineering firm. This firm started 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 1 (Laporte & Chevalier 2015).

Table 1. Classification of projects (Laporte & Chevalier 2015)

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

The firm used the project management process of the ISO 29110 series Entry Level profile to document their small-scale project management process and the project management process of the Basic Level profile to document their medium-scale project management process. The firm implemented these processes and found them useful. Based on this, they have also started documenting their systems engineering processes for the small-scale and medium scale projects using ISO 29110 series systems engineering standards for VSEs.

ISO SC7 developed “The ISO Methodology to assess and communicate the economic benefits of standards” to the standards community. This methodology was used to estimate the anticipated costs and benefits over a period of three years for several VSE developed programs. The estimates were made by the sponsors of a process definition project. Table 2 shows the results of this cost/benefit estimation.

Table 2. Costs and benefits estimations from implementing ISO 29110

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

Based on the above, it can be seen that the use of standards is a valuable asset for a VSE to incorporate within their organization for successful product development. The VSE’s use of ISO 29110 series demonstrates, to other VSEs and larger organizations that the VSE can perform and deliver a product of value, on time, and on cost. In addition, this provides a strong foundation for a prosperous and growing business for the VSE.

A case study project was created to define and implement project management and systems engineering processes at CSinTrans Inc. (CSiT), a Canadian company, created in 2011 (Laporte et al 2016a). The company specializes in the integration of interactive systems, communication and security in the field of public transport such as trains, subways, buses, railway stations, and bus stops. ISO 29110 standards and guides for systems engineering was used as the main reference for the development of the processes.

The ISO 29110 systems engineering (SE) Basic Level profile (ISO 2014), as illustrated in Figure 2, is composed of two processes: a Project Management (PM) and a System Definition and Realization (SR) process. This profile was used to document the processes of CSiT.

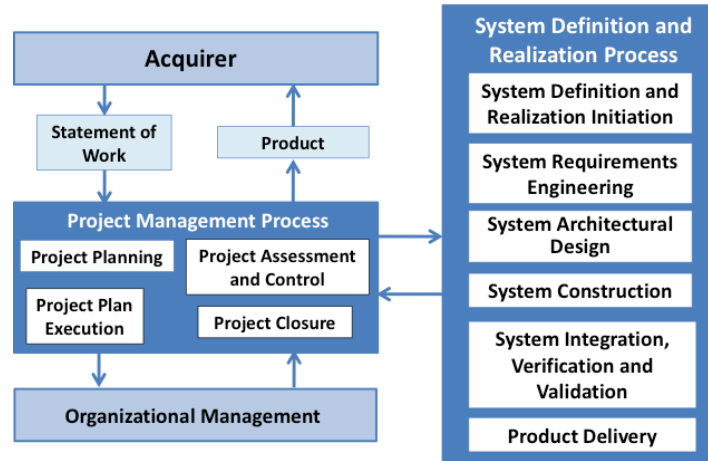


Figure 2. Processes and activities of the systems engineering Basic Profile (Laporte et al. 2016)

To better respond to different types of projects, CSiT decided to develop three process groups (i.e. light, standard, full), each being adapted to meet the attributes of projects such as the size and nature. Table 3 shows the three process groups and the frameworks to be used as reference.

Table 3. Classification of CSiT processes

	<b>Light Process</b>	<b>Standard Process</b>	<b>Full Process</b>
<b>Type of project</b>	<p>Proof of Concept, Prototype</p> <p>Concept validation or Product Deployment at Customer Site</p> <p>Small Project</p>	<p>Typical Project</p> <p>Product intended to be installed at Customer Site</p> <p>Medium Project</p>	<p>Project when CMMI level 2 is required by a Customer</p> <p>Product intended to be installed at Customer site</p> <p>Large Project</p>
<b>Framework to be used</b>	ISO/IEC TR 29110-5-6-1 - Entry profile + CMMI - Supplier Agreement Management	ISO/IEC TR 29110-5-6-2 - Basic profile + CMMI - Supplier Agreement Management	CMMI (Level 2)

Since CSiT is a system integrator, the company uses suppliers for the purchase and development of components that will be used in a product. Therefore, it was imperative for CSiT to establish a supplier management process that defines how to work with them and to reduce project risks.

The Basic profile has only a few tasks about the ‘make or buy’ decisions and follow-up actions (e.g. document, review and issue a purchase order). The Basic profile does not describe a supplier management process. This process is covered in the Intermediate profile. The CMMI®-DEV was consulted, as well as ISO/IEC/IEEE 15288, the INCOSE Handbook and the PMBOK® Guide. ISO 29110 provided a good starting point to align processes with selected level 2 and 3 practices of the CMMI®-DEV model. Compliance with the ISO 29110 allowed CSiT to be recognized as producing quality products and helped raise the maturity of the organization by implementing proven practices and developing uniform work products. ISO 29110 also helped in developing lightweight processes allowing small companies to remain flexible as well as its ability to react quickly to its customers. In 2016, the systems engineering Basic Profile of the ISO 29110 was successfully audited by a third-party audit team composed of 2 independent auditors. One member of the audit team was a systems engineering domain expert and the other was a software engineer domain expert. An ISO 29110 surveillance audit, at the request of the VSE, should be conducted in 2017.

The following tips will help VSEs become better contributors to the global market place:

- Exposure – Know who else shares similar concerns and priorities
- Management support – Bring senior leadership in early and often
- Persistence – Clearly communicate the value and urgency of your idea
- Relationships matter – Know your network, especially in the Government
- Program value – Be prepared to show quality, relevance to strategic guidance, and a means to measure success

**When: Timely source of information can deliver information, products, and other commercial opportunities valuable for consumers and business partners alike.**

This section will address the background and history leading to the formation of the INCOSE SE in VSE WG and the ISO VSE WG.

***Background and history leading to the formation of the INCOSE SE in VSE WG***

Most industries in domains such as aeronautics, defense, space, transportation, telecom, information systems, and biomedical have adopted and adapted systems engineering concepts for developing product and services. To address this for VSEs, during the 2009 INCOSE International Workshop (IW), the joint INCOSE/Association Françoise d’Ingénierie Système (AFIS) developed technical project plan (TPP) was presented to INCOSE leadership for starting a working group to address systems engineering for Very Small and Micro Enterprises (SE for VSMEs). INCOSE leadership approved the TPP and established the systems engineering for VSMEs WG. The WG has about 150 members on their distribution list.

The WG charter is to assist in the application of systems engineering for product development in very small/micro enterprises or small projects. In the context of VSMEs, these concepts are usable and configurable to improve product development efficiency (including costs and delays) and product quality. The WG goals are (Laporte et al. 2012):

- 1) to improve and make product development within VSEs more efficient by using systems engineering concepts, standards, and proven practices,
- 2) to elaborate guidance tailored to apply as either a prime or subcontractor role,
- 3) to provide the best of systems engineering techniques, methods and process for the betterment of the broad scope of domains around the globe,

- 4) to contribute standardization in the context of systems engineering, and
- 5) to support the transformation of systems engineering to a model based discipline

During the 2011 INCOSE IW, a group of systems engineers reviewed, with the ISO Project Editor Dr. Claude Laporte, the ISO 29110 series software standard for VSEs and proposed additions to the standard to meet the needs of the systems engineering community. Systems, in the context of ISO 29110, are typically composed of hardware and software components (ISO 2016). There are many engineering practices to choose from but no implementation guidance for selecting specific practices nor listing the connection between practices and specific program risks defined. The INCOSE WG conducted a survey in which it was determined that in many product development efforts, systems engineering processes are well documented but are not used. This is especially true within a VSE, mainly due to minimum personnel to accomplish the product development being worked on. Using the results of the survey, the WG established a set of requirements and created profiles (e.g., roadmaps, assemblage from one or more base standards to accomplish a particular function). They used these requirements to develop deployment packages (DPs) or guidance documents derived from the ISO 29110 for systems engineering standard, to facilitate implementation of the standards and guides. Many INCOSE members contributed to these efforts by reviewing and providing comments on the draft versions of the ISO 29110 systems engineering series and the DPs.

During the 2013 INCOSE IW VSME WG charter update, the decision to rename the working group to “Systems Engineering (SE) in VSEs” was made to more closely align with the ISO WG title. The INCOSE SE in VSE WG goals remain the same. If you are interested in contributing to this effort, please join the other members of the INCOSE SE in VSE WG by signing up for the SE in VSE WG in your INCOSE profile.

### ***Background and history leading to the formation of the ISO/IEC JTC1 SC7 VSE WG***

At the ISO/IEC JTC1 SC7 meeting in Brisbane, Australia in 2004, Canada’s representatives raised the issue of small enterprises requiring standards adapted to their size and maturity level. The current software engineering standards target (or are perceived as targeting) large organizations. Australian’s delegates supported Canada’s representatives’ position in this regard, and the two national bodies took action to investigate possible ways forward. A meeting of interested parties was held with delegates from five national bodies (Australia, Canada, the Czech Republic, South Africa and Thailand) at which a consensus was reached on the general objectives (Laporte et al. 2008):

- To make the current software engineering standards more accessible to VSEs;
- To provide documentation requiring minimal tailoring and adaptation effort;
- To provide harmonized documentation integrating available standards:
  - ☞ Process standards
  - ☞ Work products and deliverables
  - ☞ Assessment and quality
  - ☞ Modelling and tools
- To align profiles, if desirable, with the notions of maturity levels presented in ISO/IEC 15504.



It was also decided that a special interest group (SIG) be created to explore these objectives, and to better articulate the priorities in a proposed project plan. The participants felt that it would be possible, during 2004, to draw up:

- ⇒ a set of requirements;
- ⇒ an outline of key deliverables, and the associated processes to create them (e.g. how to create profiles);
- ⇒ a Terms of Reference document for the working group;
- ⇒ an example of a simple profile

At the 2005 SC 7 Plenary Meeting the Project Plan was approved and the first meeting of ISO/IEC JTC1 SC7 Working Group (WG) 24 was held. This ISO WG was mandated to develop standards and guides for VSE use, thus the work on the ISO/IEC 29110 series began to address software standards for VSEs. In November 2011, the WG met in Dublin, Ireland to launch the official development of the systems engineering standards for VSEs. Delegates from Brazil, Canada, France, Japan, Thailand, United States, and INCOSE participated in the first meeting. The Basic Level profile for Systems Engineering was published in August 2014 with the Entry Level and Intermediate Level profiles completed in 2015 and 2016 respectively. The Advance Level profile is in development now.

**Where: What information is helpful to you where you are at this moment? You know what you have, what you can do, and what potential commercial opportunities are relevant to your capabilities. You don't always know how to coordinate and provide this in a useful way for you to prosper.**

This section will address where a VSE can obtain helpful information to support their business opportunities.

OCED reports have been instrumental in the support of VSEs and their resulting products. These reports have provided several opportunities to facilitate the development, growth, and the recognition of VSEs as suppliers of high quality products and services. There are VSEs around the world creating valuable products and services for consumers, to include components used in systems, either as independent products, or incorporated into a larger system. It has been shown that most engineering standards have been developed by large organizations for use by large organizations. The ISO 29110 series is a distillation of the ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207 standards to assist and encourage VSEs to use systems engineering principals and processes to support their product development.

VSEs can be involved in efforts as an independent participant or as a member of an extended enterprise, in both traditional small projects and innovated product development to support larger projects. These efforts often induce organizational and cultural changes within the VSE itself. The adoption of these changes and potential new engineering methodologies, are important growing points for VSEs. They can include the standardization of processes, supporting tools, and supporting technologies for the engineering of systems and software products for systems.

The use of the ISO 29110 series is a way for VSEs to use systems engineering concepts and principals to support their work. The ISO 29110 series supports VSEs which do not have experience or expertise in adapting and tailoring ISO/IEC/IEEE 12207 or ISO/IEC/IEEE 15288 to the needs of a specific project. This, plus the use of the INCOSE developed DPs, can help VSEs provide a better product for their customer, while providing a way for their entity to become a qualified partner with larger organizations.

ISO 29110 Parts 1, 3, and 5 are freely available and can be downloaded from the ISO standards website. For additional VSE information, the following Web sites provide more details about the INCOSE SE for VSE Working Group and ISO 29110 efforts:

<http://www.incose.org/ChaptersGroups/WorkingGroups/transformational/VSE>.

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

**Why: You need to understand (and be able to explain) why someone would use your product or service and why a business would pay for any services you offer.**

This section will address why a VSE can provide a useful product to their customer using ISO 29110 and DPs.

As systems become larger and more complex, the control of suppliers by systems engineering organizations is critical to the success of their projects. These suppliers can include large, small, and micro organizations, or any combination thereof. OCED reports state that VSEs, due to their size, are particularly constrained from competing in many developmental efforts. These constraints can include the requirement for the VSE to follow unrealistic standard requirements for their size. The ISO 29110 series, coupled with the INCOSE SE Handbook, provided the foundation for the INCOSE developed DPs. The main goal of the INCOSE SE in VSE WG is to promote and assist in the selection, adoption, and effective utilization of “Proven Practices” by VSEs. Drawing from experienced systems engineers, the SE in VSE WG has developed the DPs with each one reviewed and edited by at least 2 persons. These DPs provide tailored processes and procedures for the VSE to adopt and use in their product realization. The DPs are designed such that a VSE can implement its content, without having to implement the complete standard at the same time. The DPs are not intended to preclude or discourage the use of additional guidelines that VSEs find useful. By deploying and implementing the DPs, a VSE can see concrete steps to achieve or demonstrate coverage of ISO 29110. The use of ISO 29110 series and the DPs provide an easy way for VSEs to overcome some of the competition constraints and deliver the required products and services to a development effort. Figure 3 shows the DP puzzle and how they fit together to support the overall product realization.

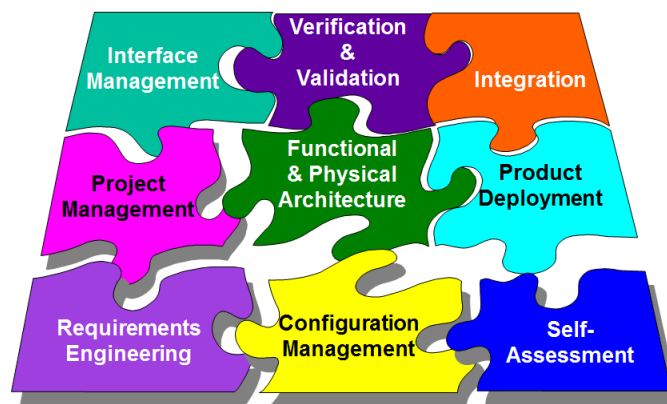


Figure 3. Systems Engineering Deployment Packages

An example of the use of a DP was presented during the IS 2016. Paper #136, *ISO/IEC 29110 Deployment Packages and Case Study for Systems Engineering: The "Not-So-Secret" Ingredients*

*That Power the Standard*, was presented by Ronald Houde. The paper describes the successful use of the Systems Engineering DP for Requirements Engineering (RE DP) and showed how it can be applied in a product development effort. The DP was used to establish the formal requirements for an Autonomous Rover. The Case Study was developed under the Eclipse Foundation Polarsys project. The Autonomous Rover prototype, developed in the Case Study was entirely built from COTS components identified in the Autonomous Rover BOM (bill of materials), many of which are Open Source (Houde et al. 2016). Figure 4 shows an image of the completed Autonomous Rover prototype. Since this presentation, successful additional capabilities have been added to the Autonomous Rover system using the RE DP to document them.

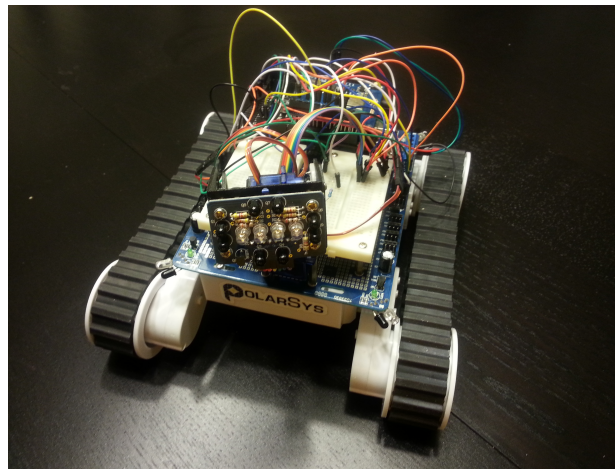


Figure 4 Autonomous Rover Prototype with IR Compound Eye (Houde et al. 2016)

### **How you deliver matters**

This section will address how a VSE can provide a useful product to their customer.

The OECD *SME and Entrepreneurship Outlook Report (2015)* reviewed the tax treatment of VSEs. Measures to ease VSEs *access to markets* have focused on *international markets*, on the one hand, and *public procurement*, on the other. The case for the use of tax preferences, with simplification measures for VSEs was developed. Ideally, taxes should be neutral with regard to the business decisions of VSEs, including decisions related to their creation, formation, and growth. The report recommends that Governments avoid introducing further tax complexities for VSEs. The taxation issues can be improved by a systematic scrutiny of new regulations, their implementation impact, and the business impact on VSEs. A system to ensure the audit and monitoring of new legislation has been introduced worldwide, with Canada, the United Kingdom, and the Netherlands leading the way to that end.

Japan has the most developed policy and institutional set-up for international markets, based upon the use of non-discriminatory measures which seek to support efforts made by VSEs themselves. Policy in this area addresses the disadvantages experienced by VSEs due to their lack of access to human resources, to external markets, and to technology. Regarding public procurement, the United States, Australia, and other OECD countries, have made comprehensive efforts to increase the “share” of government contracts which small firms obtain.

Overall, policy makers need to address the following questions, among others: do we have the appropriate support measures to address the specific set of top barriers identified? If so, are the

target VSEs sufficiently aware of them? How well does our support provision compare with international best practice? What actions are needed to improve awareness and perceived usefulness of our support programs for VSE internationalization?

***How much? The use of ISO 29110 series and INCOSE DPs can help VSEs succeed when they deliver measurable results for customers.***

The ISO SC7 WG24 developed the ISO 29110 series. The WG members established that the objectives for their work to support VSEs would:

- make the current ISO standards accessible to VSEs by (sub setting, profiling, or other approaches),
- provide turn-key material that requires minimal tailoring and adaptation effort,
- provide harmonized products that integrate available standards:
  - process standards
  - work product and deliverables
  - assessment and quality
  - modeling and tools
- provide multiple profiles generated from elements of the standards, and
- be desirable to align profiles with maturity levels.

The ISO 29110 series is based on subsets of appropriate standards elements, referred to as VSE profiles. The purpose of a VSE profile is to define a subset of ISO standards relevant to the VSE context, for example, processes and outcomes of ISO/IEC/IEEE 12207 and products of ISO/IEC/IEEE 15289 for software and ISO/IEC/IEEE 15288 and products of ISO/IEC/IEEE 15289 for systems, to encourage VSEs to use standards in developing a product. The ISO 29110 series is not intended to preclude the use of different lifecycles such as: waterfall, iterative, incremental, evolutionary, or agile.

As defined in ISO 29110 (ISO 2016), the generic VSE profile group (a collection of profiles which are related either by composition of processes (i.e. activities, tasks), or by capability level, or both.) is applicable to a vast majority of VSEs that do not develop critical systems or software. The generic profile group, as illustrated in Figure 5, is a collection of four profiles (Entry, Basic Intermediate, Advanced), providing a progressive approach to satisfying a vast majority of VSEs. The Entry profile is targeted at start-ups and at projects of 6 person-month or less. The Basic profile targets VSEs developing a single product by a single work team. The Intermediate profile targets VSEs involved in the development of more than one project in parallel with more than one work team. The Advanced profile targets VSEs which want to sustain and grow as an independent competitive system and/or software development business. The Basic profile was the first profile addressed by the WG, with work on the other profiles being at different stages of completion. For software engineering, the first 3 profiles have been published. The last one, i.e. the Advanced Profile, should be published in late 2017. The Systems Engineering Entry and Basic profiles have been published. The Intermediate profile should be published in early 2018.

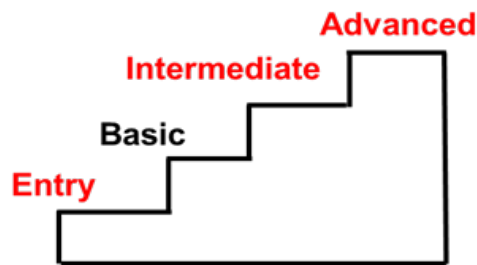


Figure 5. A four-stage roadmap for VSEs

The ISO 29110 series of documents listed in Table 4 is targeted by audience and is intended to improve the quality of products services, and the performance of processes. When a new profile is needed, ISO 29110 Parts 4 and 5 can be developed without affecting the existing documents.

Table 4. The ISO/IEC 29110 Set of Documents and Target Audience (ISO 2016)

ISO/IEC 29110	Title	Target audience
ISO/IEC 29110-1	Overview	VSEs and their customers, assessors, standards producers, tool vendors and methodology vendors.
ISO/IEC 29110-2	Framework for profile preparation	Profile producers, tool vendors and methodology vendors. Not intended for VSEs.
ISO/IEC 29110-3	Certification and assessment guidance	VSEs and their customers, assessors, accreditation bodies.
ISO/IEC 29110-4	Profile specifications	VSEs, customers, standards producers, tool vendors and methodology vendors.
ISO/IEC 29110-5	Management, engineering and service delivery guides	VSEs and their customers.

\*Note: Parts 1, 3, and 5 are available In English and French for free from ISO: <http://standards.iso.org/ittf/PubliclyAvailableStandards/index.html>

The use of the ISO 29110 series and tools can help the VSE develop a structured approach for product development, enhance their maturity, and use established best practices documented in ISO standards and the INCOSE Systems Engineering Handbook. Included in the ISO 29110 series is a mapping of the series to ISO/IEC/IEEE 12207, ISO/IEC/IEEE 15288, the INCOSE Systems Engineering Handbook, and CMMI. It is anticipated that there will be a mapping to ISO 9001 in the future. This mapping can help large organizations determine how a VSE's work can fulfill the requirements that they are following to develop the larger project.

This structured approach provides a defined way that can help VSEs qualify for contracts and sub-contracts. These contractual relationships can be with large organizations seeking to find qualified business partners, governments, or with other VSEs.

When VSEs use the ISO 29110 series it is helpful for them to use and incorporate the appropriate profile level DPs in their work efforts. The DPs, described previously, are a set of artefacts developed by the INCOSE SE in VSE WG to facilitate the implementation of a set of practices of the ISO 29110 series within a VSE. The different profile levels incrementally add additional tasks consistent with the given maturity level and are derive from profile specific parts of the ISO 29110. It is suggested that small projects use the Entry Level profile or Basic Level profile, with medium projects using the Basic Level profile or Intermediate Level profile, and large projects using the Intermediate profile or Advance profile with the PMBOK Guide of PMI.

The use of the ISO 29110 series and DPs is not intended to preclude nor discourage the use of additional guidelines that the VSE finds useful.

***How do you know that? The successful venture will develop a business model that is based on first-hand experience and measurable results of how businesses and consumers will spend their time, attention and money and what they will share with and recommend to their friends, neighbors, family and customers.***

In all countries, small firms are responsible for a limited share of total exports and imports. VSEs tend to export disproportionately more to neighboring countries than large firms do, but in many OECD countries the VSE contribution to trade with emerging economies, notably China and India, is very significant.

The ability of organizations to compete, adapt, and survive depends increasingly on quality, productivity, cycle time, and cost. VSEs developing systems or software are very important to industry based on the components they develop often being innovated and integrated into products made by larger organizations. Failure of the VSE to deliver a quality product on time and within budget may threaten both customers and suppliers. The increased use of information technologies provides multiple opportunities for reducing bureaucratic burdens on all companies, including 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 29110 series software certification process. An ISO 29110 series auditor should be competent in auditing techniques, have expertise in the ISO 29110 series, and have experience in software development. For VSEs, such a certification should not be too expensive and should be short to conduct. The certification process has been successfully piloted in a few VSEs and for these pilots, it took about 4 staff-days of work by the auditors.

Dr. Laporte made a presentation on the ISO 29110 series concepts and principals to the Government of Columbia in March of 2017. Many of their VSEs attended this presentation. Based on the presentation, the Government of Columbia has launched a program to implement ISO 29110 series nation-wide and certify a minimum of 110 VSEs in the next two years. About 85% of the cost for the implementation and certification program will be paid for by the Colombian Government. Dr. Laporte will train the consultants for the Colombian auditors. One additional benefit is that these 110 VSEs and their employees provide an opportunity to expand the membership of INCOSE in the area.

In support of the INCOSE strategic objectives, Dr. Laporte developed a list of contributions that the INCOSE SE in VSE WG can make to INCOSE. Table 5 suggests how this can be done.

Table 5. INCOSE Strategic Objectives and SE in VSE WG Contributions (Laporte 2015)

<b>INCOSE Strategic Objective</b>	<b>VSE WG Contribution</b>
INCOSE doubles its membership and embraces healthcare, mobility and energy sectors	VSEs represent over 95% of global organizations. The path to doubling INCOSE membership is through VSEs! The path to healthcare, mobility and energy sectors is also enabled through deployment packages.
Alliances. INCOSE amplifies its ability to achieve its mission through diverse alliances	VSE WG will staff booth at PMI Global Congress in Oct 14, Phoenix, AZ. VSE WG products are the natural glue between INCOSE and PMI.
Education. INCOSE curriculum recommendations are widely adopted around the world raising the quality of SE education	Can't teach from 15288, but can teach from 29110 and INCOSE VSE WG DPs.
Products	VSE WG DPs have gone viral around the world!
Forums	VSE WG DPs are an easy discussion starter and centerpiece of forums in any setting.
Competency. INCOSE teams with industry to raise competency across many domains	VSE WG DPs provide a progression through 4 profiles (entry, basic, intermediate and advanced) which enhance teaming and allow for VSEs to build competency with confidence.
Transformation. Accelerate transformation of SE to a model based discipline	VSE WG DPs augmented with MBSE initiatives provide a growth path to development of new SE foundations in tools and techniques.

To support these efforts, the INCOSE SE in VSE WG can develop the following products for VSEs (Laporte 2015):

1. INCOSE 'Certified' ISO 29110 consultants
2. INCOSE 'Certified' ISO 29110 auditors
3. INCOSE 'Certified' ISO 29110 courses
4. INCOSE 'Certified' ISO 29110 audits
5. INCOSE ISO 29110 training packages for consultants/auditors/teachers
6. INCOSE ISO 29110 case studies and cost/benefit analysis
7. INCOSE ISO 29110 Handbooks/Guides (with chapters/sections for VSEs)
  - e.g. Measurement guide, Requirements guide having material/section adapted to the needs of VSEs and to the profiles of ISO 29110
8. INCOSE ISO 29110 Systems engineering 'Start-up Kit for VSEs'
  - e.g. process, procedure, template, example, form, checklist, tools
  - INCOSE ISO 29110 'Service Delivery Kit' (e.g. service delivery process, procedure, template, example, forms)



With these products available from the SE in VSE WG, INCOSE can develop case studies, cost/benefit analysis reports, and promotional videos by an INCOSE Board leader (e.g. about ISO 29110 and INCOSE DPs implementation in a company) for industry and government agencies use. The results of these combined efforts should bring increased visibility and recognition of the positive impact of INCOSE worldwide by providing useful products to thousands of VSEs. This can lead to more systems engineering processes being used by VSEs, thereby increasing the productivity and quality of the VSEs products. Coupling this with an increased teaching of systems engineering courses in academia, using the ISO 29110 series and DPs to conduct annual student competition (e.g. Student Robot competition, a student “Best ISO 29110 Project” in industry/government, work case studies), can enlighten students and professors to the value added of INCOSE membership and products.

### **Conclusion**

Most industries in domains such as aeronautics, defense, space, transportation, telecom, information systems, and biomedical have adopted and adapted systems engineering concepts for developing product and services. The VSE use of standards provides many benefits for them to grow their business influences. These benefits include improved management of systems and software development efforts and their budgets. Their overall quality goals are more likely to be reached using standards, which can support certification. With improved employee training, personnel turnover is enhanced which can lead to attracting new customers and partnerships for co-development, particularly in a growing global environment.

The INCOSE Se in VSE WG, utilizing the ISO 29110 series to develop DPs, provides benefits to VSEs, their clients, and their business partners by delivering an easy way to start implementing systems engineering concepts and principals within their organization. The DPs have been specifically developed for VSEs providing systems and/or software engineering products. The new ‘Service Delivery’ profile being developed for ISO 29110 series will help VSEs in delivering better ‘after delivery’ services to their customers.

The ISO 29110 series, coupled with the INCOSE DPs are intended to be used by VSEs that do not have experience or expertise in adapting or tailoring larger standards to their needs for a specific project. VSEs that have expertise in adapting ISO/IEC/IEEE12207 or ISO/IEC/IEEE15288 are encouraged to use those standards instead of the ISO 29110 series.

In addition to English, the ISO 29110 series is available in Czech, English, French, German, Japanese, Portuguese, Spanish, and Arabic. Some countries have already adopted ISO 29110 series as their national standard.

For additional VSE information, the following Web sites provide more details about the INCOSE SE for VSE Working Group and ISO 29110 efforts:

<http://www.incose.org/ChaptersGroups/WorkingGroups/transformational/VSE>.

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

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### **Biography**

Ken Ptack is an INCOSE Founder and ESEP Number 102. He is a consultant for small and large organizations providing systems engineering support for all size systems. He has worked in the aerospace and defence industry for over 40 years. He has a Bachelor of Science Degree in Naval Engineering and a Master of Science Degree in Systems Analysis. He is the Secretary of ISO/IEC JTC1 SC7 WG24, Co-chair of INCOSE Systems Engineering in VSE WG, member of the INCOSE Requirements WG, the INCOSE Standards WG, and was the INCOSE President in 1999.