

## Designing Systems Engineering Profiles for Very Small Entities

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**Abstract.** To address the systems lifecycle needs of Very small entities, a set of standards and guides have been recently developed using the systems engineering lifecycle standard ISO/IEC/IEEE 15288 as the main framework. The systems engineering handbook, developed by the International Council on Systems Engineering (INCOSE), is used as the reference for the development of a set of systems engineering deployment packages. This short paper presents an overview of this new systems engineering standard and discusses certification scheme needs and future developments.

**Keywords:** VSE, ISO/IEC 29110, ISO, System Engineering Standards, ISO/IEC/IEEE 15288

### 1 Introduction

A wide variety of approaches exist to guide software and systems engineering development with a significant number of situational factors [1] influencing the decision of which approach to use. For example, some approaches emphasize the importance of human interaction [2] and the transfer of tacit knowledge [3] between team members and others champion the meticulous execution of a systematic process. However, it is commonly agreed that no single approach is universally implemented and it seems likely that no single approach can be universally useful [4], primarily as no two settings are identical [5].

To assist very small companies in tackling this problem, relatively new software and systems engineering lifecycle standards has been introduced, known as ISO/IEC 29110 Lifecycle profiles for Very Small Entities [6]. The approach [7, 8] used to develop ISO/IEC 29110 started with the pre-existing international standard ISO/IEC/IEEE 12207 [22] dedicated to software process lifecycles [9]. The overall approach consisted of three steps: (1) Selecting ISO/IEC/IEEE 12207 process subset applicable to VSEs of up to 25 people; (2) Tailor the subset to fit VSE needs; and (3) Develop guidelines for VSEs. There has been numerous papers written about the design and introduction of the ISO/IEC 29110 Lifecycle profiles for Very Small Entities standard [10, 11, 12] which specifically addresses the software lifecycle needs of Very Small Entities (VSEs) has been defined as being “*an enterprise, organization, department or project having up to 25 people*” [13]. Furthermore several publications have presented the results of early stage evaluations and pilot projects to implement this standard in software development companies in several [14, 15, 16]. This short paper concentrates on the design and development of the next

major stage of this standard, which is an extension to specifically address the Systems Engineering (as opposed to software engineering) needs of VSEs and the development of the ISO/IEC TR 29110-5-6-2:2014 - Systems Engineering Lifecycle Profiles for Very Small Entities (VSEs)' [18].

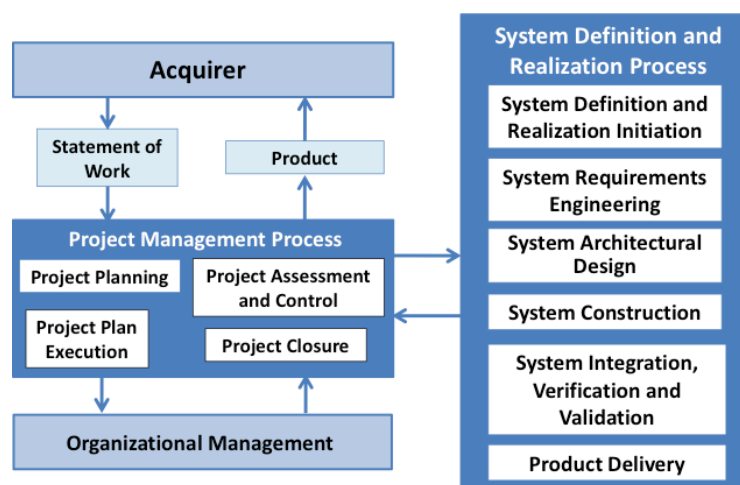
At the SC7 Plenary meeting in France in May 2011, the ISO/IEC 29110 project editor submitted, on behalf of Canada, a formal project proposal to develop a set of systems engineering standards for VSEs similar to the set developed for software VSEs. A draft systems engineering Management and Engineering guide for the Basic profile was attached to the formal proposal. The scope of this work includes the current scope of ISO/IEC/IEEE 15288, the associated guidance documents and other relevant SC7 Standards such as ISO/IEC/IEEE 15289 and ISO/IEC 29110. The project will produce Standards and Technical Reports (Guides), similar to the ISO/IEC 29110 set of Software documents for the Generic profile group (i.e. for VSEs developing non critical system), which establishes a common framework for describing assessable system engineering life cycle profiles for Very Small Entities (VSEs). 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.

## 2 The Systems Engineering Basic Profile

The Basic profile, as illustrated in Figure 1, as for the software engineering Basic profile which was used to develop the systems engineering Basic profile, is composed of two processes: a Project Management (PM) process and a System definition and Realization (SR) process. As defined in ISO/IEC 29110, the purpose of the Project Management (PM) process is to establish and carry out in a systematic way the tasks of the system development, which allows complying with the project's objectives in the expected quality, time and cost. The objectives of the ISO/IEC TR 29110-5-6-2 Project Management Process of the Basic profile are [18]:

- **PM.O1.** The Project Plan, the Statement of Work (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.
- **PM.O2.** Progress of the project is monitored against the Project Plan and recorded in the Progress Status Record. 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 Acceptance Record.
- **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.
- **PM.O4.** Review meetings with the Work Team and the Acquirer, suppliers are held. Agreements are registered and tracked.

- **PM.O5.** Risk Management Approach 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.O6.** A Product Management Strategy is developed. Items of Product are identified, defined and baselined. 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.O7.** Quality Assurance is performed to provide assurance that work products and processes comply with the Project Plan and System Requirements Specifications.
- **PM.O8.** A Disposal Management Approach is developed to end the existence of a system entity.



**Fig 1.** Processes of the systems engineering Basic Profile

The purpose of the System Definition and Realization (SR) process is the systematic performance of the analysis, design, construction, integration, verification, and validation activities for new or modified system according to the specified requirements. The seven objectives of the SR process are [18]:

- **SR.O1.** Tasks of the activities are performed through the accomplishment of the current Project Plan.
- **SR.O2.** System requirements are defined, analyzed for correctness and testability, approved by the Acquirer, baselined and communicated.
- **SR.O3.** The System architectural design is developed and baselined. It describes the System elements and internal and external interfaces of them. Consistency and traceability to system requirements are established.
- **SR.O4.** 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.O5.** System elements are integrated. Defects encountered during integration are corrected and consistency and traceability to System Architecture are established.

- **SR.O6.** A System Configuration, 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.O7.** Verification and Validation Tasks 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, and corrected; records are stored in the Verification/Validation Reports.

Each objective of ISO/IEC 29110 is linked to processes of a standard. For example, objective SR.O5 is linked to ISO/IEC 15288:2008, 6.4.5 Integration Process, with just 2 of the 4 outcomes, of the integration process of ISO/IEC/IEEE 15288 being selected for the Basic profile.

So far, two Canadian systems engineering organizations have implemented the ISO/IEC 29110: a 4-person start-up VSE in the transportation field [23] and a large engineering firm. In the engineering firm, a cost and benefit study, using the ISO methodology to assess and communicate the economic benefits of standards [24], has showed significant savings from the implementation of ISO/IEC 29110 [20].

### 3 Future Work

Having developed ISs and TRs for VSEs involved in the development of software, WG24 developed the ISO/IEC 29110 systems engineering Basic profile management and engineering guide. Then members of the INCOSE VSE WG developed a set of Deployment Packages to help implement the Basic profile. WG24 started the development of the Entry profile for systems engineering. Once a stable version of the SE Entry profile is available [17], the INCOSE VSE working group will be able to start the development of the deployment packages to support the Systems Engineering Entry Profile. Once the ISO/IEC 29110 software Intermediate and Advanced profiles are ready, the development of the two matching systems engineering profiles for VSEs will start. Since many VSEs developing systems are also involved in the development of critical systems, WG24 and the INCOSE VSE Working Group will conduct an analysis to determine if a set of systems/software engineering standards for VSEs developing critical systems should be developed [19, 20]. Finally, the ISO/IEC 29110 SE profile specifications [21] should be published in 2015. This document, ISO/IEC 29110-4-6, will be an international standard and will be required by the auditors when they perform a systems engineering ISO/IEC 29110 audit. The certification scheme is based on ISO Standards on Conformity Assessment.

### References

1. Clarke, P. and O'Connor, R., The situational factors that affect the software development process: Towards a comprehensive reference framework, *Journal of Information and Software Technology*, Vol. 54, Issue 5, May 2012. pp. 433-447
2. Ryan, S., and O'Connor, R.V., Acquiring and sharing tacit knowledge in software development teams: An empirical study. *Information and Software Technology*, Vol. 55, No. 9, pp. 1614-1624, 2013.

3. Ryan, S., O'Connor, R.V.: Development of a team measure for tacit knowledge in software development teams. *Journal of Systems and Software*, Vol. 82, 229–240 (2009)
4. Jeners, S., O'Connor, R.V., Clarke, P., Lichter, H., Lepmets M. and Buglione, L., Harnessing software development contexts to inform software process selection decisions, *Software Quality Professional*, Vol. 16, No.1, pp. 35-36 (2013).
5. Jeners, S., Clarke, P., O'Connor, R. V., Buglione, L., and Lepmets, M. Harmonizing Software Development Processes with Software Development Settings – A Systematic Approach, In McCafery, F., O'Connor, R.V. and Messnarz R. (Eds), *Systems, Software and Services Process Improvement*, CCIS 364, Springer-Verlag, 2013
6. International Organization for Standardization (ISO): ISO/IEC TR 29110-5-1-2 Software engineering - Lifecycle profiles for Very Small Entities (VSEs) Part 5-1-2: Management and engineering guide: Generic profile group: Basic profile, Geneva (2011). Available at no cost from ISO at: [http://standards.iso.org/ittf/PubliclyAvailableStandards/c051153\\_ISO\\_IEC\\_TR\\_29110-5-1\\_2011.zip](http://standards.iso.org/ittf/PubliclyAvailableStandards/c051153_ISO_IEC_TR_29110-5-1_2011.zip)
7. O'Connor, R.V., Laporte, C.Y., An Innovative Approach to the Development of an International Software Process Lifecycle Standard for Very Small Entities, *International Journal of Information Technology Systems Approach*, Vol. 7, No. 1, pp. 1-22, 2014.
8. 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, 2013.
9. Clarke, P., O'Connor, R.: Harnessing ISO/IEC 12207 to Examine the Extent of SPI Activity in an Organisation. In: Riel, A., O'Connor, R., Tichkiewitch, S., Messnarz, R. (eds.) *EuroSPI 2010*. CCIS, vol. 99, pp. 25–36. Springer, Heidelberg (2010).
10. O'Connor, R., Basri, S. and Coleman, G., Exploring Managerial Commitment towards SPI in Small and Very Small Enterprises, in Riel et al (Eds), *Systems, Software and Services Process Improvement*, CCIS Vol. 99, Springer-Verlag, pp. 268-278, 2010.
11. O'Connor, R. V. and Sanders, M., Lessons from a Pilot Implementation of ISO/IEC 29110 in a Group of Very Small Irish Companies, In Woronowicz, T., Rout, T., O'Connor, R.V., and Dorling A., (Eds), *Software Process Improvement and Capability dTermination*, CCIS Vol. 349, Springer-Verlag, May 2013
12. O'Connor, R., Evaluating Management Sentiment Towards ISO/IEC 29110 in Very Small Software Development Companies. In: Mas, et al. (eds.) *Software Process Improvement and Capability Determination*. CCIS, vol. 290, pp. 277–281. Springer-Verlag, Heidelberg (2012).
13. Laporte, C.Y., Alexandre, S., and O'Connor, R., A Software Engineering Lifecycle Standard for Very Small Enterprises, R.V.O'Connor et al (Eds) *Proceedings of EuroSPI* Springer-Verlag, CCIS Vol. 16, pp. 129-141 (2008).
14. O'Connor, R., Laporte, C.: Deploying Lifecycle profiles for Very Small Entities: An Early Stage Industry View. In: O'Connor, et al. (eds.) *Software Process Improvement and Capability Determination*. CCIS, vol. 155, pp. 227–230. Springer-Verlag, Heidelberg (2011)
15. O'Connor, R. and Laporte, C.Y., Using ISO/IEC 29110 to Harness Process Improvement in Very Small Entities, Workshop on SPI in SMEs, 18th European Software Process Improvement Conference, CCIS Vol. 172, Springer-Verlag, 2011.
16. O'Connor R. and Laporte, C.Y., Towards the provision of assistance for very small entities in deploying software lifecycle standards. In *Proceedings of the 11th International Conference on Product Focused Software (PROFES '10)*. ACM, (2010)
17. ISO/IEC DTR 29110-5-6-1:2014 - Systems and Software Engineering – Lifecycle Profiles for Very Small Entities (VSEs) - Systems Engineering Management and engineering guide: Generic profile group: Entry profile, Geneva, Switzerland: International Organization for Standardization/International Electrotechnical Commission. Will be available at no cost from ISO at: <http://standards.iso.org/ittf/PubliclyAvailableStandards>
18. ISO/IEC TR 29110-5-6-2:2014 - Systems and Software Engineering –Lifecycle Profiles for Very Small Entities (VSEs) – Part 5-6-2 - Systems Engineering - Management and engineering guide: Generic profile group: Basic profile, International Organization for

Standardization/International Electrotechnical Commission: Geneva, Switzerland.  
Available at no cost from ISO at: <http://standards.iso.org/ittf/PubliclyAvailableStandards>

19. Laporte, Claude Y., Houde, R., Marvin, J., Systems Engineering International Standards and Support Tools for Very Small Enterprises, Paper to be presented at the 24th Annual International Symposium of INCOSE (International Council on Systems Engineering), Las Vegas, US, June 30th-July 3, 2014.
20. Laporte, C. Y., O'Connor, R. V., A Systems Process Lifecycle Standard for Very Small Entities: Development and Pilot Trials, Barafort, B., O'Connor, R.V. and Messnarz R. (Eds), Systems, Software and Services Process Improvement, CCIS 425, Springer-Verlag, Heidelberg (2014)
21. ISO/IEC CD 29110-4-6:2014 Systems and software engineering — Lifecycle Profiles for Very Small Entities (VSEs) — Part 4-6: Systems Engineering profile specifications: Generic Profile Group, Geneva, Switzerland: International Organization for Standardization/International Electrotechnical Commission.
22. ISO/IEC/IEEE 12207:2008, Systems and software engineering - Software life cycle processes, Geneva, Switzerland: International Organization for Standardization/International Electrotechnical Commission, 2008.
23. Laporte, C.Y., O'Connor, R., Garcia Paucar, L.H., Gerançon, B., An Innovative Approach in Developing Standard Professionals by Involving Software Engineering Students in Implementing and Improving International Standards, International Cooperation for Education about Standardization Conference, August 14th 2014, Ottawa, Canada.
24. Economic benefits of Standards - ISO Methodology 2.0, International Organization for Standardization, Geneva, Switzerland, 2010. Freely available from ISO at: [http://www.iso.org/iso/home/standards/benefitsofstandards/benefits\\_of\\_standards.htm](http://www.iso.org/iso/home/standards/benefitsofstandards/benefits_of_standards.htm)