

A viability analysis of the ISO/IEC 29110 project management process: a case study in an automotive ecuadorian company

Un análisis de viabilidad del proceso de gestión de proyectos del estándar ISO/IEC 29110: un estudio de caso en una compañía automotora ecuatoriana

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Abstract—Software process standards such as the ISO/IEC 29110 have been implemented by Very Small Entities (VSE) in order to develop quality software and achieve improvements in terms of time, budget, documentation, and other subjects. The generic profile group established in such a standard includes a set of profiles with situational factors of occurrence applicable to some VSEs. However, documented case studies of the ISO/IEC 29110 implementation in Latin America companies are limited, causing uncertainty about the viability of such a standard in VSEs established in the region. Different conditions of each environment—company type, size, country, etc.—can influence the implementation of a software project. Such a fact can affect the possibility of quality improvement by using the standard. In this paper we implement the project management process included in the basic profile of the ISO/IEC 29110 in an automotive Ecuadorian company. We identified extra effort—17.30%—and overruns—17.06%—triggered by implementing the project management process in this exercise are within the parameters defined and evaluated in previous literature. Besides, we summarize a set of lessons learned acquired during such an implementation. Finally, the findings of this study will allow VSEs to decide whether is convenient to implement this standard in such an environment.

Index Terms—ISO Standards; ISO/IEC 29110; Software Engineering; Very Small Entities.

Resumen—Los estándares de procesos de software tales como ISO/IEC 29110 se implementan en organizaciones pequeñas (en inglés, *Very Small Entities*, VSE) con el fin de desarrollar software de calidad y lograr mejoras en términos de tiempo, presupuesto, documentación y otros campos. El grupo de perfiles genéricos establecido en dicha norma incluye un conjunto de perfiles con factores situacionales de ocurrencia aplicables a algunas VSEs. Sin embargo, los casos de estudio documentados sobre la implementación de ISO/IEC 29110 en empresas de América Latina son limitados, generando incertidumbre sobre la viabilidad de tal estándar en VSEs establecidas en la región. Las diferentes condiciones de cada entorno—tipo de empresa, tamaño, país, etc.—pueden influir en la implementación de un proyecto de software. Este hecho puede afectar la posibilidad de mejora de la calidad mediante el uso de la norma. En este estudio se implementa

el proceso de gestión de proyectos incluido en el perfil básico de la norma ISO/IEC 29110 en una empresa automotriz ecuatoriana. Se identifica que el esfuerzo adicional—17,30%—y los sobrecostos—17,06%—provocados por la implementación del proceso de gestión de proyectos en este ejercicio se encuentran dentro de los parámetros definidos y evaluados en la literatura. Además, se resume un conjunto de lecciones aprendidas durante dicha implementación. Finalmente, los hallazgos de este estudio permitirán a las VSEs decidir si es conveniente implementar este estándar en dicho entorno.

Palabras claves—Estándares ISO, ISO/IEC 29110; Ingeniería de Software; PYME.

I. INTRODUCTION

ADAPTABILITY, competitiveness, and even survival of an organization depend even more on software efficiency. The role of traditional software developers in companies—especially in VSEs—has been evolving and growing in terms of methods, documentation, structure, and more [1]. The ISO/IEC 29110 Systems and Software Life Cycle Profiles and Guidelines for Very Small Entities was developed in order to fulfill this emerging need. Since the release of the ISO/IEC 29110, organizations have adopted such a standard in order to find balance for allowing documentation and standardization of processes [2], [3], [4], [5], [6], [7]. Even though the initial effort for implementing the standard is larger—10 % to 18 % of rework—, some improvement in several implementation aspects can be achieved in medium term [8].

The generic profile group defined in the management and engineering guide of the systems engineering part of the ISO/IEC 29110 contains a collection of profiles including processes, activities, tasks, and roles. Laporte *et al.* [1] define a profile as “a kind of matrix that identifies which elements should be taken from existing standards.” The basic profile is suitable for developing a single noncritical system at a time operating in conjunction with any development lifecycle. The basic profile includes two main processes: project management

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and software implementation.

Some case studies related to VSEs have been documented in some countries—especially in North America, Asia, and Europe—since the appearance and formalization of the ISO/IEC 29110 [2], [3], [5], [7], [8], [9]. However, considering the large number of VSEs, the amount of previous studies developed in Latin America is minimal compared to other regions. Therefore, an opportunity for evaluating and implementing the standard in different environments is viable [9]. Some companies are unaware of the ISO/IEC 29110 due to lack of knowledge and resources for implementing such a standard [10], [11], [12]. Likewise, some organizations are unable to find trustable data in order to verify whether the standard can be applied to a specific scenario. The actual diversity of companies around the world—infrastructure, geographical location, service or product types, number of employees, and market targets—generates different impact of the standard on each organization [13]. Such heterogeneity plays a crucial role in the success rate a standard implementation could have.

In this paper, we implement the part 5-6-2: management and engineering guide by using the project management process included in the basic profile of the ISO/IEC 29110 in an automotive Ecuadorian company. We perform each activity concerning the process—planning, execution, evaluation, control, and closure. We also evaluate the process in terms of cost and time in order to determine the impact of a first-time implementation of the project management process. Finally, we summarize a set of lessons learned acquired during the implementation.

We intend to determine the viability of the project management process included in the basic profile in a singular Ecuadorian VSE. Conclusions of this study are intended to reach a starting point for VSEs interested in applying the ISO/IEC 29110 in the Latin America region.

The rest of the paper is organized as follows. Structure and concepts of the ISO/IEC 29110 standard are introduced in Section 2. The required background and related studies are described in Section 3. In Section 4 we propose the implementation of the project management process in an automotive Ecuadorian company, and the results obtained are then defined in Section 5. The main discussion is described in Section 6, and the conclusions along with possible lines of future work are presented in Section 7.

II. ISO/IEC 29110 STANDARD

The ISO/IEC 29110 standard “Lifecycle profiles for Very Small Entities” [14] is developed to meet the VSEs emerging need for creating quality software and improving the process in terms of time, efficiency, economic benefits, and documentation. The management and engineering guide includes a four-profile set—entry, basic, intermediate, and advanced. Each profile includes additional progressive activities and elements [1]:

- 1) Entry profile. For start-up VSEs.
- 2) Basic profile. For the development of a single application.
- 3) Intermediate profile. For the development of multiple

projects together with multiple development teams.

- 4) Advanced profile. For independent software development businesses.

In addition, the basic profile is based on two processes: Project Management (PM) and System Definition and Realization (SR) as shown in Fig 1 [14]. Each process includes activities and roles involved in a specific order. However, VSEs have freedom for choosing the method in order to implement the standard. According to ISO [14], the ISO/IEC 29110 lacks the inclusion of a specific procedure for executing such an implementation; also, it can be applied to any life cycle model—agile, incremental, waterfall, iterative, etc. Therefore, the resulting effect among organizations using the standard may

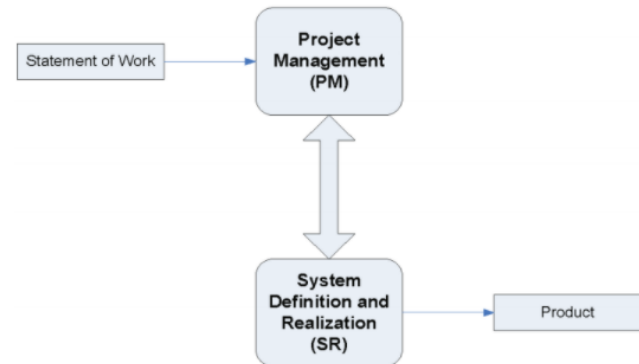


Fig. 1. Basic profile guide processes [7].

vary.

A set of roles is defined for each process in order to accomplish the tasks of each activity. The project manager elaborates a project plan which is established as a guide in the operation and it has to be followed by the team in order to develop the project in the SR process.

According to Sanchez *et al.* [11], the number of VSEs adopting the standard has grown. Besides, results obtained from the literature review of case studies related to the ISO/IEC 29110 implementation point to a positive impact on the final product and other surrounding factors [9], [8], [10].

III. BACKGROUND AND RELATED STUDIES

The Organization for Economic Co-operation and Development (OECD) performs a study for evaluating the amount of SME (small and medium-sized enterprises) around the world. According to OECD [15], “SMEs constitute the dominant form of business organisation in all countries worldwide, accounting for over 95% and up to 99% of the business population depending on country.” 85% of the information technology (IT) organizations in Europe have up to 10 employees [1]. In Brazil, 95% of the companies have up to 19 people working on it [1]. In Peru, 96% of IT organizations can be considered as VSEs [16]. According to Salazar *et al.* [17], around 160 IT companies in Ecuador, composed 93% of VSEs. However, in 2012, ProChile together with Universidad Casa Grande [18], elaborated a statistical study about the development of software in Ecuador, showing 651 companies registered as IT organizations, with a growing market share of

12% per year. Nevertheless, as shown in Fig. 2, only 24.6% of software companies have adopted quality standards internationally recognized, leaving a tremendous opportunity

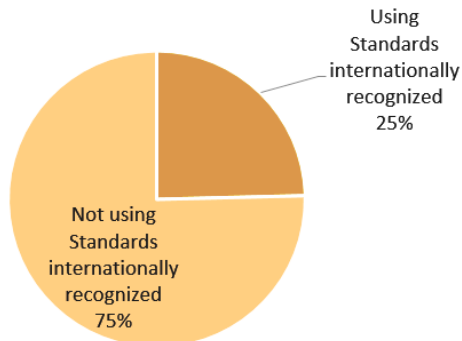


Fig. 2. Ecuadorian Companies with Quality Standards internationally recognized.

and vast unexplored fields in the country [18].

Some VSEs are unfamiliar to the ISO/IEC 29110 standard due to circumstances such as lack of support and resources, time constraints, and other [19]. Likewise, documented studies about the standard implementation are limited, diminishing the capacity of companies for making decisions in terms of the ISO/IEC 29110 implementation.

Previous work comprises case studies focused mostly in North America and Canada. Laporte [9] resumes nine of such case study implementations. According to Laporte [9] “A one-person VSE can learn from ISO 29110 to better organize work and produce quality software.” A case study documented by Laporte [10] on a Canadian division of a large American engineering company was intended to determine the economic benefits of a 3-year projection, obtaining as result almost 4% of net profits per year. In Peru, Romero [16] documented a case study developed in a relatively short time. The result led to an improvement in the work process, solid documentation methods, and the implementation of the ISO/IEC 29110 basic profile. A case study of two VSEs in Peru was presented by Diaz *et al.* [20]. According to the authors, the implementation in VSEs requires the company CEO support for the standard fulfillment success. Vera [21] implements a method for eliciting requirements based in pre-conceptual schemas by using the basic profile of the ISO/IEC 29110. Such a method was validated in two case studies involving a research project financed by a Colombian governmental institution and a ceramic manufacturing company [21], [22]. Sanchez *et al.* [11] try to identify issues regarding the adoption of the ISO/IEC 29110 in Ecuador. The authors interview employees from three VSEs concluding the lack of the ISO/IEC 29110 implementation in the country is due to certain factors such as length and difficult procedures, lack of resources, lack of experts in the field, and low acceptance of quality standards in the region.

Even though the ISO/IEC 29110 is unrelated to any lifecycle, it was associated with Agile Software Development Methodologies (ASDM). According to Chow *et al.* [23],

ASDMs are primarily targeted at small and very small organizations or teams. Galvan *et al.* [24] assess a compliance level of three main agile software development methodologies with the ISO/IEC 29110 project management process by using the entry profile. The authors conclude UPEDU (Unified Process for Education) has the highest compliance level, followed by SCRUM, and finally XP (Extreme Programming) with some lacks.

The ISO/IEC 29110 standard has been also used for teaching purpose. Bougaa *et al.* [25] proposed a teaching method for system engineering fundamental knowledge. Such an adaptive new path is focused on undergraduate students who are new to the discipline.

Although case studies developed in companies have been isolated, common variables of the previously performed research have been identified. In most cases, enterprises have considerable improvement in many aspects—time, expenses, documentation, etc. Likewise, as part of the lessons learned from previous work, one of the most common recommendations is the early implementation of just one process of the ISO 29110. Consequently, we aim to implement the project management process in our case study.

IV. PROJECT MANAGEMENT PROCESS IMPLEMENTATION

The implementation includes the standard review and the creation of a unique document including all activities and results obtained during the management process. In addition, in the exercise we use the waterfall lifecycle model when developing the project.

A. Study Company

Orange Software&Solutions Cia. Ltda. is a three-year company established in the south of Ecuador aimed to improve organizational processes by developing software applications. The company has four employees for software development purposes. The organization is attempting to implement the ISO/IEC 29110 in a software project for an automotive dealership. For confidentiality reasons, we will call AVD to the customer company.

B. Problem background

The company AVD needs a repair-process-automation system in the after-sales department. Administrative personnel want to supervise the complete workflow of the process, starting with the client arrival, and ending with the vehicle delivery. The implementation is coordinated along with the IT department and the after-sales staff.

C. Project planning

The project management process involves a set of four activities—project planning, project plan execution, project assessment and control, and project closure—in order to accomplish the construction and monitoring of the project plan. The first activity is called “project planning” and it includes a set of steps developed to manage the project. The steps conducted by the team in the project plan activity involving this case study are described as follows:

1) Previous evaluation

- Review of each activity and task description in order to establish its viability.
- Creation of a work breakdown structure of the main project management process containing all activities to be followed. Such a structure includes the resulting work products, the flow of information between activities, and a visual map of the whole process as illustrated in Fig. 3.

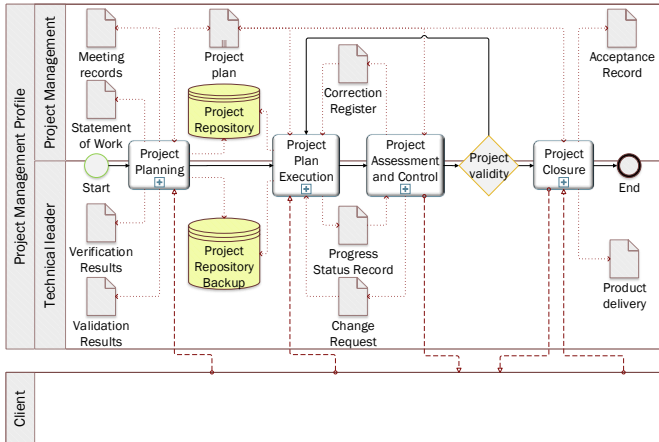


Fig. 3. Project Management Processes diagram of the ISO 29110 systems engineering.

2) Work products

- Review of the resulting work products, both inbound and outbound.
- Elaboration of structure templates for each work product. Templates created are described as follows:
 - Statement of Work
 - Project plan
 - Product delivery
 - Verification Results
 - Validation Results
 - Meeting records
 - Project Repository
 - Project Repository Backup
 - Progress Status Record
 - Change Request
 - Correction Register
 - Acceptance Record.

3) Client documentation

- Creation of documents relative to the client in order to settle all agreements reached in the meetings:
 - Documents
 - Meeting records

4) Roles

- Identification of roles established in the standard including responsible involved in all activities. As shown in Table I, the technical leader role was omitted. The decision was made due to the small size of the project. Therefore, the project manager accomplishes the activities of the technical leader.

TABLE I
PROJECT MANAGEMENT ROLES INVOLVED IN THE PROJECT

Role	Abbreviation	Job
Customer	CUS	After-sales manager, Workshop Manager, IT Manager
Project Manager	PM	Country Manager
Work Team	WT	Analyst, Developer

5) Statement of work

- Elaboration of the statement of work according to the first meeting with the customer.
- Definition of the project requirements, scope, delivery dates, responsible, purpose, and objectives.

6) Repository

- Creation of the repository structure with the work team in order to standardize the development process and version control.
- Establishment of the repository to be stored in a cloud. The structure used for the project is shown in Fig. 4.

7) Initial schedule

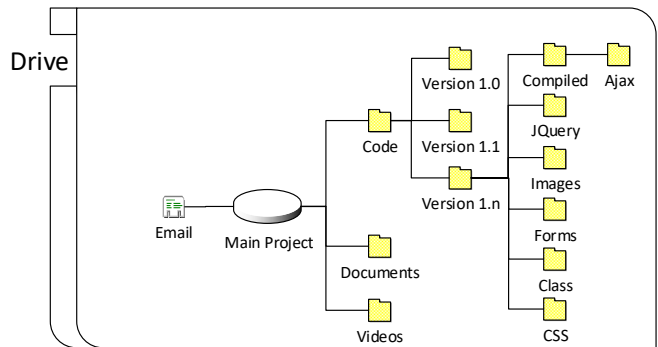


Fig. 4. Repository Tree diagram.

- Definition of the software development lifecycle. The summary of planned activities is shown in Fig. 5. Several sub-activities can be developed simultaneously and have been detailed in the main resulting document.

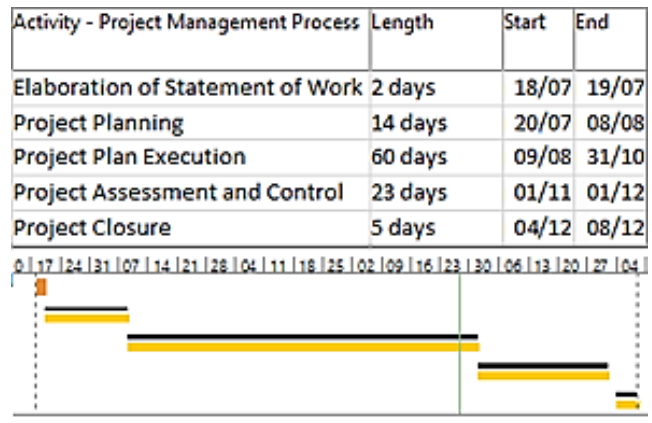


Fig. 5. Gantt diagram of the initial project schedule.

D. Project plan execution

The project plan execution includes the following steps performed by the team:

- Development of the deliverable.
- Conduction of constant meetings with both client and work team for attending issues—either problem-solving or regularly planned meetings—by following the standard recommendations.
- Deployment of the deliverable.
- Sharing of the final document created with the client in order to be validated.

V. RESULTS

A. Project assessment and control

After implementing the project plan execution, we develop a progress status record which contain the results obtained from planned versus real metrics in terms of tasks,

TABLE II
PLANNED VERSUS REAL METRICS IN TERMS OF TASKS FULFILLMENT PERCENT (TIME MEASURED IN DAYS)

Task	Plan	Real	Gap	Accomplish
Statement of work	2	4	+2	100%
Project planning	14	21	+7	100%
Project plan execution	60	69	+9	100%
Project assessment and control	23	23	0	100%
Project closure	5	5	0	100%

TABLE III
OBJECTIVES ACCOMPLISHED PERCENT

Objective	Accomplish
Minimize the delivery time of damaged vehicles	N/A
Comply with the estimated date for delivering vehicles	N/A
Define sub-processes and states	100%
Quantify time spent on each process	100%
Identify the responsible roles of each process	100%
Generate a historical record of future decisions and plans	100%
Identify delay problems in real time	100%
Improve the relationship with the client	N/A

TABLE IV
PLANNED VERSUS REAL METRICS IN TERMS OF RESOURCES USED PERCENT

Resource	Plan	Real	Gap	Accomplish	
Human	Project Manager	1	1	0	100%
	Technical Leader	1	0	-1	0%
	Developer	3	3	0	100%
Equipment	Laptop	4	4	0	100%
	Printer	1	1	0	100%
	Router	1	1	0	100%
Property	Office	1	1	0	100%
Supply	Toner	1	1	0	100%
	Paper sheets	50	50	0	100%
	Folders	10	10	0	100%
Furniture	Desks	4	4	0	100%
	Chairs	4	4	0	100%
Digital	ISO/IEC 29110	1	1	0	100%

TABLE V
PLANNED VS. ACTUAL METRICS IN TERMS OF BUDGET

Variable	Plan	Real	Gap	%
Project cost (usd)	1,950,00	2,288.72	+338.72	17.06
Working days	104	122	+18	17.30
Daily work hours	4	4	0	0
Cost per hour (usd)	4.68	4.69	0	0

TABLE VI
PLANNED VERSUS REAL METRICS IN TERMS OF RISKS

Risk	Plan	Real	Gap
Delay in response from the after-sales department	10%	5%	-5%
Delay in response from IT Manager	100%	100%	0%
Identification of serious errors in final stages of development	5%	5%	0%
Survey of new requirements in final stages of development	10%	20%	+10%
Dropout of employees in final stages	10%	0%	0%
Restrictions of deliverable installation by the IT department	50%	70%	+40%
Delayed meetings with the client	10%	30%	20%

objectives, resources, budget, and risks as illustrated in Tables II to VI.

B. Cost overruns

According to the Standish Group “CHAOS Report,” [26] the probabilities of a software project resolution are divided into three categories called “Standish Resolutions:” type 1 for complete success corresponding to 29%, type 2 for significant schedule delays over budget corresponding to 53%, and type 3 for canceled failed projects corresponding to 18%. However, a 56% average budget overrun is linked to Standish Resolutions type 2 and type 3.

Matiscola [27] provides a method used to cost-justify software project effectiveness. The variables used in this method are:

- 1) E_E = Expected expenditure on software development, estimated at \$1,950.00
- 2) P_f = Project probability to have a Standish Resolutions type 2 or type 3 termination, estimated at 71%
- 3) R_o = Average budget overrun for Standish Resolutions type 2 and type 3, estimated at 56%
- 4) R_f = Ratio of the cost of projects with Standish Resolutions type 2 and type 3
- 5) B = Initial budget
- 6) E_o = Budget overruns.

$$R_f = 1 + R_o \quad (1)$$

Thus, R_f will be 156%.

$$B = E_E / (P_f (R_f - 1) + 1) \quad (2)$$

Thus, B is estimated at about \$1,395.25.

$$E_o = E_E - B \quad (3)$$

The budget overruns limit for Standish Resolutions type 2 and type 3 is estimated at \$554.75 (1), (2), (3)

VI. DISCUSSION

According to Laporte *et al.* [8] between 10 % and 18 % of rework is done in a first-time implementation of the ISO/IEC 29110. The current results showed a gap of 18 days in the task fulfillment schedule, resulting in a 17.30% delay, leaving the estimated time delay within the parameters defined and evaluated in previous case studies.

In order to have an acceptable software project result in terms of budget, according to Matiscola [27] the cost overruns should be under the limit for Standish Resolutions type 2 and type 3. Such a limit is estimated at \$554.75 in this case study. However, the real budget overruns for the project were \$338.72, leaving the cost overruns within the estimated range described in the method.

Regarding the results obtained from the progress status record, we can conclude in terms of activities delay, the project took over 17.30% more implementation time. Such a fact meant almost 4 weeks over the initial schedule. In terms of objectives accomplished, 7 out of 10 objectives were accomplished at a 100% rate. However, the remaining objectives lack dependency on the software implementation. In terms of resources used, we lack the inclusion of a technical leader in the project, being the only missing resource. In terms of budget, we expend \$2,288.72 as project cost, being \$338.72 more expensive than initially planned budget. Such an expense represents a 17.06% over budget. In terms of risks, we assure the bigger problem was the lack of regularity from stakeholders, generating delays for meetings and new requirements in final stages of the development.

A. Lessons learned

During the process implementation, some issues appeared. The employee transition between working in improvised environments to a framework where the process is previously defined—documents, activities, work products, roles, tasks, schedule, etc.—resulted in some difficulties at the beginning of the exercise. The lack of communication between the client and the VSE resulted in time delays because some stakeholders reject to plan the meetings. Such stakeholders were careless in the way they execute and organize their activities and schedule. A different working method has to be instilled in order to accomplish a regular, planned, and consistent way for developing the project. An anticipated negative perception of the customer alleging the implementation of ISO standards is a waste of economic resources and staff time. Some issues found in the standard included lack of information for implementing methods and lifecycles.

On the other hand, the advantages found in the process included:

- 1) Improvement in work organization
- 2) Use of measures such as task fulfillment, delay time, objectives, resources, budget, risks
- 3) Definition of roles
- 4) Creation of standardized document templates

- 5) Clear initial statement of work
- 6) Definition of the project scope
- 7) Elaboration of the schedule including tasks, activities, dates, and duration
- 8) Elaboration of a project plan as a map to be followed along the process
- 9) Definition of a change request process in order to attend and solve requests from the customer
- 10) Creation of the progress status record containing all the resulting data, offering the possibility of comparing planned results versus real results.

Finally, general recommendations VSEs should consider when implementing the ISO/IEC 29110 are:

- 1) Unconditional support from the CEO
- 2) Sufficient resources such as human, equipment, supplies, budget, time, infrastructure
- 3) Initial evaluation of the current company processes
- 4) Availability for training
- 5) Defined objectives
- 6) Knowledge of the ISO/IEC 29110 and the implementation method to be used
- 7) Defined lifecycle
- 8) Schedule meeting organization

VII. CONCLUSION

In this paper, we studied the development and implementation of the project management process by using the basic profile of the ISO/IEC 29110 in an automotive Ecuadorian company. We also studied the process and activities developed by the work team along the lifecycle. Likewise, we feature the progress status record for evaluating the planned scenario vs the real scenario. With the compiled information, we summarized a set of lessons learned involving positive and negative statements. Finally, we qualified the gap in terms of time and cost when developing a first-time implementation of the standard. The findings of this study validate the possibility to properly plan and execute projects by using the ISO/IEC 29110 in VSEs located in the region. Benefits found in this research far outweigh the problems encountered in the process.

Finally, we propose for future research to expand the number of case studies in Latin America companies which are implementing the standard. Future case studies should include project management and software implementation process along with other lifecycle models and different profiles of the management and engineering guide.

REFERENCES

- [1] C. Y. Laporte, N. Séguin, G. V. Boas and S. Buasung, "Small tech firms Seizing the benefits of software and systems engineering standards," *Rev. ISO Focus+*, vol. 4, no. 2, pp. 32-36, Feb. 2013.
- [2] A. Buchalceva, "Methodology for ISO/IEC 29110 Profile Implementation in EPF Composer," *International Journal of Information Technologies and Systems Approach*, vol. 10, no. 1, pp. 61-74, 2017. DOI: 10.4018/IJITSA.2017010104
- [3] R. Eito, "Ontology-based Tailoring of Software Process Models," *Terminology and Knowledge Engineering 2014*. Berlin, pp. 1-10, Jun. 2014.

- [4] L. García, C. Y. Laporte, Y. Arteaga and M. Bruggmann, "Implementation and Certification of ISO/IEC 29110 in an IT Startup in Peru," *Software Quality Professional*, vol. 17, no. 2, pp. 16-29, Mar. 2015.
- [5] R. V. O'Connor, "Early Stage Adoption of ISO/IEC 29110 Software Project Management Practices: A Case Study. Software Process Improvement and Capability Determination," 14th International Conference, *SPICE 2014 Vilnius*. Communications in Computer and Information Science. Lithuania, A. Mitasiunas, T. Rout, R. O'Connor and A. Dorling, eds., Springer-Cham, vol. 477, pp. 226-237, 2014. DOI: 10.1007/978-3-319-13036-1_20
- [6] P. Rodríguez-Dapena and M. F. Buitrago-Botero, "How to Certify the Very Small Entity Software Processes Using ISO/IEC 29110," *Communications in Computer and Information Science 526 - Software Process Improvement and Capability Determination - 15th International Conference, SPICE 2015*. Gothenburg, pp 245-252, Jun. 2015. DOI: 10.1007/978-3-319-19860-6_20
- [7] V. Siddoo, N. Wongsai and R. Wetprasit, "An Implementation Approach of ISO/IEC 29110 for Government Organizations," *Lecture Notes in Computer Science*, vol. 7983, pp. 5-19, 2013.
- [8] C. Y. Laporte, N. Tremblay, J. Menaceur and D. Poliquin, "Implementing the New ISO/IEC 29110 Systems Engineering Process Standard in a Small Public Transportation Company," *Systems, Software and Services Process Improvement EuroSPI 2016*, C. Kreiner, R. V. O'Connor, A. Poth and R. Messnarz, eds., Springer-Cham, Graz, pp. 15-29, Sep. 2016. DOI: 10.1007/978-3-319-44817-6_2
- [9] C. Y. Laporte and R. V. O'Connor, "Implementing Process Improvement in Very Small Enterprises with ISO/IEC 29110 A Multiple Case Study Analysis," 2016 10th International Conference on the Quality of Information and Communications Technology, Lisbon, pp. 125-130, Sep. 2016. DOI: 10.1007/978-3-319-44817-6_2
- [10] C. Y. Laporte and F. Chevalier, "Economic benefits of ISO/IEC 29110 Standard: a Case Study," *Substance Scientific News and Innovation from ÉTS*, Sep. 2015.
- [11] M. L. Sanchez-Gordon, R. V. O'Connor and R. Colomo-Palacios, "Evaluating VSEs Viewpoint and Sentiment towards the ISO/IEC 29110 Standard: A two Country Grounded Theory Study," *Software Process Improvement and Capability Determination SPICE 2015*, T. Rout, R. V. O'Connor and A. Dorling, eds., Springer-Verlag, Gothenburg, pp. 114-127, Jun. 2015. DOI: 10.1007/978-3-319-19860-6_10
- [12] N. Wongsai, V. Siddoo and R. Wetprasit, "Factors of Influence in Software Process Improvement: An ISO/IEC 29110 for Very-Small Entities," 2015 7th International Conference on Information Technology and Electrical Engineering, Chiang Mai, pp. 12-17, Oct. 2015. DOI: 10.1109/ICITEED.2015.7408904
- [13] M. L. Sánchez-Gordón and R. V. O'Connor, "Understanding the gap between software process practices and actual practice in very small companies," *Software Quality Journal*, vol. 24, no. 3, pp. 549-570, Sep. 2016. DOI: 10.1007/s11219-015-9282-6
- [14] ISO, "ISO/IEC TR 29110-5-6-2: 2011 - Software Engineering - Lifecycle profiles for Very Small Entities (VSEs) - Part 5-6-2: Systems engineering — Management and engineering guide: Generic profile group: Basic profile," Geneva, 2014.
- [15] Organisation for Economic Co-operation and Development, "OECD SME and Entrepreneurship Outlook - 2005 Edition," Paris, 2005.
- [16] M. Abarca-Romero, R. Arisaca-Mamani and A. Dávila-Ramón, "Implementación del perfil básico de la ISO/IEC 29110 de una pequeña empresa desarrolladora de software: Lecciones aprendidas," *Industrial (INDUSTRIAL 2015) en XVIII Congreso Ibero Americano de Ingeniería de Software (CIB-SE 2015)*, Lima, Apr. 2015.
- [17] D.R. Salazar, M. K. Villavicencio, M.V. Macias and M. Snoeck, "Estudio estadístico exploratorio de las empresas desarrolladoras de software asentadas en Guayaquil, Quito y Cuenca," *ESPOL - VLIR Componente 8 Ingeniería de Software*, pp. 1-15, Oct. 2003.
- [18] Oficina Comercial de ProChile en Ecuador, Universidad Casa Grande, C. Andrade, J. S. Proaño, D. Ricaurte, J. Sáenz, "Estudio de mercado servicio desarrollo de software en Ecuador," 2012. [Online]. Available: http://www.prochile.gob.cl/wp-content/files_mf/documento_11_19_12112936.pdf.
- [19] C. Y. Laporte, "The Development and Experimentation of an International Standard for Very Small Entities Involved in Software Development," *Inter-national Council on Systems Engineering (INCOSE) Workshop*, Phoenix, AZ, Jan. 2011.
- [20] A. Díaz, C. de Jesús, K. Melendez and A. Dávila, "ISO/IEC 29110 Implementation on two Very Small Software Development Companies in Lima. Lessons Learned," *IEEE Latin America Transactions*, vol. 14, no. 5, pp. 2504-2510, May. 2016. DOI: 10.1109/TLA.2016.7530452
- [21] A. Vera. "A Pre-conceptual-schema-based method for eliciting requirements in the context of ISO/IEC 29110," M.Sc. thesis, Universidad Nacional de Colombia, Medellín, Feb, 2019.
- [22] A. Vera, C. M. Zapata, "Implementación de la ISO/IEC 29110 en la etapa de educación de requisitos usando esquemas preconceptuales en una corporación multinacional," *Transformación Digital en las Organizaciones*, Centro de Investigación y Desarrollo Profesional, CIDPRO Editorial , pp. 23-54 , Nov 2019. DOI: 10.29018/978-9942-823-15-1
- [23] T. Chow and D. B. Cao, "A survey study of critical success factors in agile software projects," *Rev. Journal of Systems and Software*, vol. 8, no. 6, pp. 961-971, Jun. 2008. DOI: 10.1016/j.jss.2007.08.020
- [24] S. Galvan, M. Mora, R. V. O'Connor, F. Acosta and F. Alvarez, "A Compliance Analysis of Agile Methodologies with the ISO/IEC 29110 Project Management Process," *Procedia Computer Science*, vol. 64, pp. 188-195, Oct. 2015. DOI: 10.1016/j.procs.2015.08.480
- [25] M. Bougaa, R. V. O'Connor, S. Bornhofen and A. Rivière, "A Standard Based Adaptive Path to Teach Systems Engineering: 15288 and 29110 Standards Use Cases," 11th Annual IEEE International Systems Conference, Montréal, Apr. 2017. DOI: 10.1109/SYSCON.2017.7934712
- [26] J. Johnson, "My Life Is Failure: 100 Things You Should Know to be a Successful Project Leader," *Standish Group International*, West Yarmouth, MA, 2006.
- [27] S. P. Masticola, "A Simple Estimate of the Cost of Software Project Failures and the Breakeven Effectiveness of Project Risk Management," *First International Workshop on the Economics of Software and Computation (ESC'07)*, Minneapolis, MN, May. 2007. DOI: 10.1109/ESC.2007.1



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