Assessing ISO/IEC29110 by means of ITMark:

results from an experience factory

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ABSTRACT

ISO/IEC 29110 is intended to help very small entities in improving their software processes. However, this standard is not the only initiative devoted to help organizations in these matters. For instance, ITMark is a established method with an important background in terms of number and diversity of assessments. The aim of this paper is to present a method to assess ISO/IEC 29110 by means of the evaluation performed under the ITMark certification schema built upon an experience factory. To do so, in this paper authors present, firstly a mapping for ITMark to ISO/IEC 29110 and secondly a study is to test the applicability of the assessments made by ITMark in the ISO/IEC 29110 environment taking into account the previous mapping. The main conclusion from this industrial experience is that ITMark can be used as method for assessing VSEs.

KEYWORDS: ITMark, ISO/IEC29110, Experience Factory, VSE.

1. INTRODUCTION

Software is considered one of the leading industries today [1]. This industry affects the competitiveness of a country [2] or even of the whole society. A majority of firms within software industry are relatively small in all countries [3]. As a result of this, the study of SMEs in software industry is vastly present in the scientific literature and studies on different countries are pervasive e.g. [2,4–8].

According to the European Union regulations, A SME can be defined as a company presenting less than 500 employees [5]. Software companies are affected for aspects like time in business, management style, size, market sector, product range and location [9]. One important factor for all companies is size. As a consequence of this importance, the term very small entity (VSE) was defined by the ISO/IEC JTC1/SC7 Working Group (WG) 24 as an entity (enterprise, organization, department or project) having up to 25 people. ISO/IEC 29110 Standard, developed back in 2011, provides a lightweight process model developed for VSEs providing guidelines standards, technical reports as well as support artifacts for these kind of companies. However, and in spite of its attractiveness its adoption is still limited due to the inner characteristics of SMEs and their software processes and business environments [10]. There is still empirical evidence of the long term results of the application of this standard. However there is relatively small and documented and positive evidence on the results of the implementation of heavier models in small organizations like, for instance

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CMMI [11]. In contrast, there is also strong evidence on the difficulties of the application of these kind of models in small organizations [12,13]. Thus, in a scenario in which the adoption of the aforementioned ISO/IEC 29110 standard is important to sustain the competiveness of software VSEs, counting on with mechanisms to ensure its adoption or assessment will improve its repercussion. The aim of this paper is to present an approach to assess ISO/IEC 29110 by means of the evaluation performed under the ITMark certification schema built upon an experience factory.

The remainder of this paper is organized as follows. Section 2 introduces insights and related literature on experience factories, ITMark and ISO/IEC29110. Section 3 presents the mapping developed between ITMark and ISO/IEC29110. In Section 4, the study performed is presented including design, results and discussion. Section 5 includes main conclusions and future research directions.

2. RELATED LITERATURE

2.1 Experience factories

The single most valuable asset of a software company or department is the knowledge and experience of its people [14], in order words, given that the software industry is intensive in human capital [15], packaging and reusing the knowledge and competence is key to ensure the sustainability of this business.

According to [16], the experience factory is an organization (logical and/or physical) supporting projects by gathering and analysing previous experiences in the form of a repository for such experience with the final aim to deliver such experience on demand. Another definition of the term is provided in the work of [17]. In this paper, author underlines that an experience factory aims at addressing the issues of quality improvement by providing a mechanism for continuous improvement through the experimentation, packaging and reuse of previous experiences adapter to organizational needs.

The concept of experience factory is key in the reuse of postmortem experiences and products in the software engineering field [18]. It is also seen as an enabler for organizational learning, although the support of a separate support organization is needed to manage and learn from its own experience [19]. Such need could be one of the reasons behind the fact that few organizations have the resources to adopt the experience factory approach [18]. However, and in spite of this barrier, the influence of the approach is obvious in recent works in the software engineering field including aspects like requirements [20], global software projects and their communication issues [21] or simple knowledge management systems applied to VSEs [22]. In the VSE´s environment, by being part of a community, VSEs could share experiences and practices to take advantage of others' experiences and knowledge and finally improve their software processes [23].

Due to the difficulties in deploying an experience factory, in this paper, authors present an initiative to build an experience factory in which the support organization is an assessor in the ITMark certification scheme. This is an advantage in costs (making the experience factory feasible for SMEs and VSEs), but also a new way to deploy a multi-organizational experience factories based on the assessments made in the ITMark certification scheme. In the next subsection, the main highlights of this initiative are presented.

2.2 ITMark

ITMark is an initiative leaded by European Software Institute (ESI) aimed to certify software companies assessing their software process. A good introduction to the initiative can be found in [24]. According to these authors, ITMark incorporates three different quality reference

models: Business processes model; software, systems and services engineering model and, finally, security management model. In what follows, the three models are depicted.

Business Processes Model

The model presents ten specific categories as follows: market, management, products & services, sales, marketing and distribution, strategy and committee, financial analysis, customer's profile and analysis, investment factors, development and production, and industry and macro environment. Categories are composed by ten elements to be assessed. As a consequence, business process model contains a hundred elements characterizing business aspects.

Software, Systems and Services Engineering model

This model is based on CMMI® and is structured in several process areas. This assessment method is focused on maturity levels 2 and 3 of the reference model and is including the following process areas for its basic level: CM (Configuration Management), PPQA (Process and Product Quality Assurance), MA (Measurement and Analysis), REQM (Requirements Management), PP (Project Planning), PMC (Project Monitoring and Control) and, finally, SAM (Supplier Agreement Management).

Security Management model

ITMark is based on ISO/IEC 27000 and includes the following attributes: confidentiality, integrity and availability based. The approach adopted is the adaptation of these ISO requirements to SMEs (Small and Medium Enterprise). There are 61 aspects analyzed in the initiative. Figure 1 shows the main aspects present in the initiative and their reference to the standard.

ITMark ID	**Reference to the Standard**
A1. There is a basic inventory of assets	7.1.1 Inventory of assets
A2. Assets have their owner formally identified	7.1.2 Ownership of assets
A3. There is a policy for information classification	7.2 Information classification
A4. There are procedures for information classification	7.2 Information classification
A5. Some roles and responsibilities have been assigned	8.1.1 Roles and Responsibilities
A6. Security responsible have received specialized training on security	8.2.2 Information security awareness, education, and training
A7. There is a physical security	9 Physical and environmental security perimeter
A8. There are uninterruptible power supply equipments	9.2.2 Supporting utilities
A9. There are utilities for the secure disposal of information	9.2.6 Secure disposal of re-use of equipment 10.7.2 Disposal of media
A10. Each user has an unique identifier	11.5.2 User identification and authentication

A11. Permissions are assigned on users' roles and responsibilities	11.2.2 Privilege management 11.2.3 User password management
A12. Personal firewall protect local machines services	10.6.2 Security of network services 11.7.2 Teleworking
A13. User desktops and laptops are periodically updated	10.1.2 Change management 12.4.1 Control of operational software 12.5 Security in development and support processes 12.6 Technical vulnerability management
A14. Server machines are periodically updated –0.1.2 Change management	10.1.2 Change management 12.4.1 Control of operational software 12.5 Security in development and support processes 12.6 Technical vulnerability management
A15. There are mechanisms to protect-against malware	10.4 Protection against malicious and mobile code
A16. There are procedures to backup and restore data	10.1.1 Documented operating procedures 10.5 Back-up
A17. A plan for backups is set and carried out	10.5 Back-up
A18. Backup copies are labeled and stored in a secure place	10.5 Back-up
A19. Backup copies are tested periodically	10.5 Back-up
A20. Networks controls are configured and deployed	10.6 Network security management 11.4 Network access controls
A21. The organisation has identified an information security responsible	6.1.3 Allocation of information security responsibilities
A22. Employees sign confidentiality agreements	6.1.5 Confidentiality agreements 8.1.3 Terms and conditions of employment
A23. The organisation signs confidentiality agreements with clients and providers	6.1.5 Confidentiality agreements
A24. The organisation knows applicable" legislation	15.1 Compliance with legal requirements
A25. The organisation watches the observance of intellectual property rights	15.1.2 Intellectual property rights
A26. The organisation fulfils LOPD Requirements	15.1.4 Data protection and privacy of personal Information
A27. The organisation fulfils LSSICE Requirements	15.1 Compliance with legal requirements

A28. Information systems security controls are periodically verifies to guarantee compliance	15.2.2 Technical compliance checking

Table 1. Excerpt of ITMark security aspects.

ITMark has been tested and analyzed in the scientific literature and cited many times among SPI initiatives by several authors e.g. [24–28].

2.2 ISO/IEC 29110

This standard is designed to specifically address the software life cycle needs of VSEs. As documented in several papers e.g. [29], works started in the first meeting of ISO/IEC JTC1 SC7 WG24 back in 2005 and, since then, WG24 issued a series of documents to support VSEs developing software [30].

The core of the ISO/IEC 29110 standard is a management and engineering guide (ISO/IEC 29110-5) that is aimed to cover project management along with implementation issues. The aim of this first aspect is to draw a systematic path to guide the tasks of software projects, keeping the objectives of quality, time and cost.

One key aspect in the standard is the concept of profile groups. They are defined as a collection of profiles which are related either by composition of processes, by capability level, or both. Currently there are 4 main profiles: entry, basic, intermediate and advanced. Each profile builds on the previous process, adding more process supports for larger or more complex project as the VSE grows and matures. A good introduction of all features and characteristics of the standard could be found in [31].

Back in 2014, the work by [32] presented a study to measure the influence of the standard in the literature. Conclusions show an overall scarce impact. However, in current times, literature has witnessed an increasing interest in the initiative with relevant papers mentioning ISO/IEC 29110 to support aspects like effort estimation [33], success factors for SPIs initiatives [34], other standardization activities [35,36] or service management models [37], naming just some of the most relevant and recent cases. Moreover, there are also papers devoted to investigate key aspects or additions to the norm, like assessment [38], certification [39], practices assessment [9] or product quality improvement [40].

3. THE MAPPING

In present days SPI activities can be guided by a panoply of models, standards and methodologies. These improvement models and initiatives are aimed to simply management activities and to provide the necessary support in SPI projects where a single reference model is being adopted but also where there is not an environment to guide the task of working simultaneously with more than one reference model [41]. In cases in which the adoption of different models, standards and methodologies is indicated, one of the solutions to tackle effectiveness in the process is harmonization [42]. Standards and models harmonization is not an easy task [43] that needs specific frameworks to guide the process [44]. Literature has reported several efforts in the harmonization of initiatives like ISO/IEC 15504 and CMMI [45,46], ISO/IEC 9001:2000 and CMMI-DEV [47] or CMMI-DEV and PMBOK [48] citing some of the most relevant cases.

Mappings are integral parts of these harmonization frameworks. Mappings allow the identification of differences and similarities between multiple models to be carried out. Mapping is a comparison technique frequently used in scientific literature. According to [47] a mapping process should follow these steps:

1. Analyze the models
2. Design the mapping
3. Carry out the mapping
4. Present the outcomes
5. Analyze the results

In what follows, the mapping performed is described using the method provided.

MODELS ANALYSIS

The first activity is to analyze each reference model involved in a mapping process. ITMark and ISO/IEC 29110 are studied in detail. Authors have been involved in several consultancy activities analyzing and applying these models. An overview of these reference models are described in related literature section of this paper.

MAPPING DESIGN

Following the guidelines provided in [47], the following activities are carried out:

1) Identification of process entities to be compared: ITMark involves three reference models, and authors identified for each of them which process entities should be compared. With regards to business management reference model, the EFQM nine criteria are taken into account. For CMMI DEV reference model, just the process areas' specific practices are used for this mapping. For security aspects process entities are also identified.

(2) Direction of the comparison: the direction is from ITMark to ISO/IEC 29110.

(3) Comparison scale definition: authors use a Likert scale for the one to one mapping. This scale is also used in the works of [47]: strongly (coverage 86-100%), largely (coverage 51-85%), partially (coverage 16-50%), weakly (coverage 1-15%) and non-related (coverage 0%).

(4) Comparison template definition: All these numerical values are analyzed and checked from a holistic point of view and authors determine to what extent ISO/IEC 29110 goals are fulfilled.

MAPPING

This mapping is an iterative process in which authors analyze each reference model with ISO/IEC 29110. For example, for CMMI DEV all level 2 process areas are studied. Authors identified specific practices and specific goals. The objective is not to set a naïve approach between CMMI DEV specific practices' names and ISO/IEC 29110 activities' names. In this mapping, authors analyze also whether CMMI DEV specific goals and ISO/IEC 29110 activities' goals are also meet. For carrying out these mappings, a first relationship between reference models is defined. This is the case for security aspects described in Table 1. Then, a drilling down process analyzing in detail these relationships helps us to identify fine grained relationships. All these mapping are managed by using several spreadsheets where ITMark reference models are displayed as rows, and ISO/IEC 29110 statements are displayed as columns. As a consequence of this process and given the relationship between ITMark and CMMI DEV, 123 aspects related to CMMI DEV maturity level 2 are analyzed and compared to ISO/IEC29110.

OUTCOMES

Based on the guidelines provided in [47], the document Result Of Comparison compiles these mappings and is shared and agreed among authors. Table 2 shows the resulting mapping just for CMMI DEV specific practices. Each column has a fulfilment result based on the intersection of each reference model element.

S strongly (coverage 86-100%) L largely (coverage 51-85%) P partially (coverage 16-50%) W weakly (coverage 1-15%) - non-related (coverage 0%)		Project Management Process							Software Implementation Process						
		PM.O1. The Project Plan	PM.O2. Progress of the project is monitored against the Project Plan and recorded in the Progress Status Record.	PM.O3. The Change Requests	PM.O4. Review meetings	PM.O5. Risks	PM.O6. A software Version Control Strategy	PM.O7. Software Quality Assurance	SI.O1.Project Plan.	SI.O2. Software requirements	SI.O3. Software architectural and detailed design	SI.O4. Software components	SI.O5.Test Cases and Test Procedures.	SI.O6. A Software Configuration	SI.O7. Verification and Validation
	Results	S	S	S	S	S	S	S	S	S	W	W	W	S	P
DEV_CM_SP0101	41,20%						L								
DEV_CM_SP0102	73,51%						P								
DEV_CM_SP0103	50,69%	P					P		P	W	W	W	W		
DEV_CM_SP0201	47,67%													L	
DEV_CM_SP0202	54,17%													L	
DEV_CM_SP0301	51,50%													P	
DEV_CM_SP0302	18,13%													P	P
DEV_MA_SP0101	38,33%		W	p				P						P	P
DEV_MA_SP0102	41,13%		W	p				P						P	P
DEV_MA_SP0103	33,51%		W	p				P						P	P
DEV_MA_SP0104	31,49%		W	W				P						P	P
DEV_MA_SP0201	41,78%		W	W				P						P	P
DEV_MA_SP0202	34,15%		W	W				P						P	P
DEV_MA_SP0203	35,92%		W	W				P						P	P
DEV_MA_SP0204	40,85%		W	W				P						P	P
DEV_PMC_SP0101	46,99%		S												
DEV_PMC_SP0102	61,11%		S												
DEV_PMC_SP0103	34,89%					W									
DEV_PMC_SP0104	37,04%		L												
DEV_PMC_SP0105	51,26%		L												
DEV_PMC_SP0106	54,37%				W										
DEV_PMC_SP0107	42,50%				W										
DEV_PMC_SP0201	61,11%		L												
DEV_PMC_SP0202	56,94%		L												
DEV_PMC_SP0203	41,34%		L												
DEV_PP_SP0101	57,29%	S													
DEV_PP_SP0102	51,39%	S													
DEV_PP_SP0103	61,42%	S													
DEV_PP_SP0104	47,22%	S													
DEV_PP_SP0201	54,54%	S							L						
DEV_PP_SP0202	54,17%					W									
DEV_PP_SP0203	57,78%	S							L						
DEV_PP_SP0204	67,22%	S							P						
DEV_PP_SP0205	63,54%	S							P						
DEV_PP_SP0206	57,29%	S							P						
DEV_PP_SP0207	50,69%	S							P						
DEV_PP_SP0301	50,69%	S			W										
DEV_PP_SP0302	63,43%	S			W										
DEV_PP_SP0303	67,80%	S			W										
DEV_PPQA_SP0101	30,20%							X							
DEV_PPQA_SP0102	22,60%							X							
DEV_PPQA_SP0201	28,96%							X							
DEV_PPQA_SP0202	30,32%							X							
DEV_REQM_SP0101	61,46%									L					
DEV_REQM_SP0102	73,61%									L					
DEV_REQM_SP0103	57,99%			W										W	
DEV_REQM_SP0104	47,22%			W						P	W	W	P		
DEV_REQM_SP0105	50,35%			W						P	W	W	W		P

Table 2. Mapping between CMMI DEV level 2 specific practices to ISO/IEC 29110 Basic profile elements.

The comparison reveals that ITMark areas do not include engineering aspects. Therefore the current mapping does not cover 100% the ISO/IEC 29110. This means that, for instance, "SI.O3. Software architectural and detailed design, SI.O4. Software components, and SI.O5.Test Cases and Test Procedures" from this standard are not covered 100% by ITMark. However, it is also important to note that ITMark has different levels depending on each organization, and the engineering aspects can be included in its calibration.

Measurement and Analysis process area is transversal to the ISO/IEC29110 basic profile. While we are defining "quality assurance" or "change request" or "progress of the project monitored against the project plan and recorded in the progress status record", we require the definition of some measurements and indicators. Therefore this practice is not taken into account explicitly. However it is assumed implicitly.

The result of this mapping is a template to be able to assess ISO/IEC 29110 based on ITMark previous assessments. This is an effort that makes sense given the set of available ITMark assessments and the growing importance of ISO/IEC 29110 in the industry. In the next section, authors present a study devoted to investigate the coverage of ISO 29110 in real environments by means of the use of ITMark assessments and the mapping presented in this section. The final aim is to test the applicability of the assessments made by ITMark in the ISO/IEC 29110 environment.

4. THE STUDY

4.1 Method

The overall objective of the study is to test the applicability of the assessments made by ITMark in the ISO/IEC 29110 environment. The method will be as follows. Taking into account the assessments made in the ITMark schema around the world it is aimed to test the overall coverage of the ISO/IEC 29110 process areas.

4.2 Sample

Authors analyzed 74 assessments based on Software, Systems and Services Engineering process model. These assessments include the following countries: Portugal, Spain, France, Croatia, Bosnia Herzegovina, Moldova, Serbia, Armenia, Bulgaria, Republic of Macedonia, Republic of Kosovo, Albania, Australia, Argentina, Peru, Ecuador and Colombia.

4.3 Results

The 74 assessments made were based on Software, Systems and Services Engineering process model which is based on CMMI DEV level 2 process areas. Figure 1 represents the frequency of Software, Systems and Services Engineering process area fulfillment. The x-axis represents the percentage of fulfillment and y-axis its frequency in these 74 VSEs. The result follows a normal distribution and which mean is 46,99%, and which standard deviation is 0,15. These values indicate that most of the initial assessments are similar and VSE falls most of the times on the same problems. In terms of ISO/IEC29110 basic profile areas these problems come from Quality Assurance, Change Request, Software Configuration and Verification and Validation.

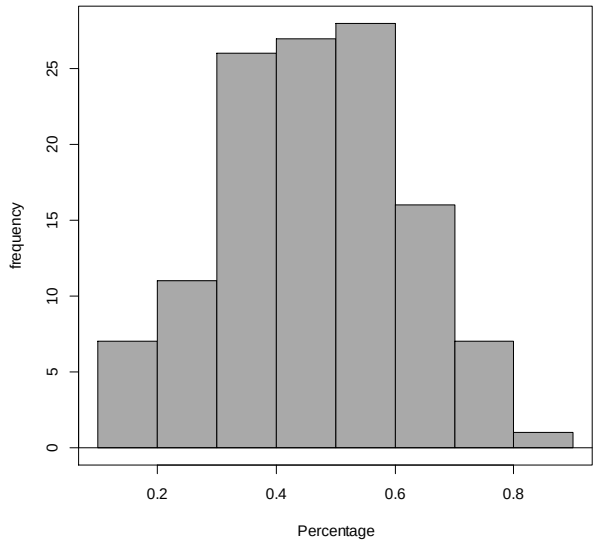

Figure 1 Frequency of achievements for Software, Systems and Services Engineering

These 74 assessments also included an evaluation of security management aspects (*Figure 2*). The ISO/IEC29110 does not define a specific profile for security concerns. This is why our mapping does not include these elements. However this aspect is part of the results of the 74 assessments. Therefore it is evaluated, and *Figure 2* represents the results for security aspects from these 74 assessments. The scale values for security are from 0 to 2. This result reveals that this kind of organizations is not taking into consideration security aspects.

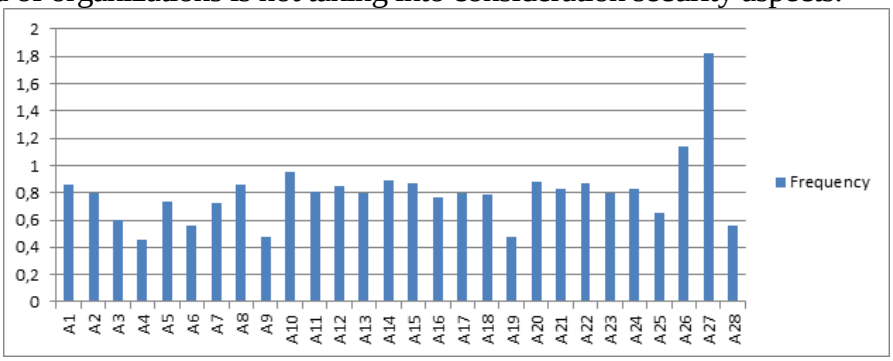

Figure 2 Frequency for Security aspects

Another aspect not included in ISO/IEC29110 is the business process model. The ISO/IEC29110 does not define a specific profile for business process model concerns. Therefore our mapping does not include this aspect, but it is part of the 74 assessments. *Figure 3* provides an overview of one aspect of business process model elements that it is called "development and production" on ITMark. The scale values for business process model area are from 0 to 2. This result reveals that this kind of organizations is applying business process model practices to their business.

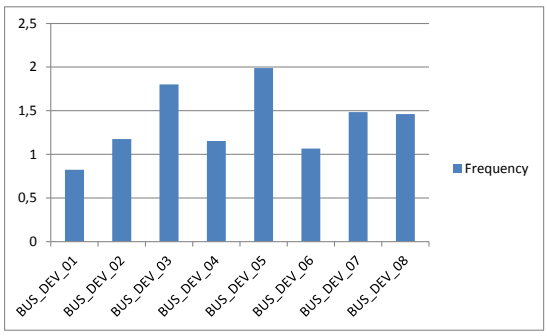

Figure 3 Frequency for Business process area: Development & Production

5. CONCLUDING REMARKS AND FUTURE WORKS

The main conclusion from this industrial experience is that ITMark can be used as method for assessing VSEs. In fact, we have used ITMark and a mapping to ISO/IEC29110 basic profile to assess VSEs. These mappings are defined and applied following Baldassarre et al. approach [47].

These 74 assessments in industrial settings reveal that the percentage of Software, Systems and Services Engineering process area fulfilment is really encouraging. In fact, their mean is around 46.99%. This result is relevant to manage the perception of required efforts for VSEs. Traditionally VSEs do not embark on process improvement initiatives or they are more reluctant to initiate this kind of activities. These assessments demonstrate that they are currently not too far from satisfying all practices.

Another relevant aspect that result from this experience is that the ISO/IEC29110 basic profile areas where VSEs have more problems are Quality Assurance, Change Request, Software Configuration and Verification and Validation. This kind of activities is usually set aside, and they are not fully carried out by VSEs.

In addition, the ISO/IEC29110 basic profile does not include security and business process model aspects. Therefore one of our current research works is to extend ISO/IEC29110 with two extensions: one for security aspects, and another for business process models.

According to [49] seems to be reasonable to perform an analysis of VSEs related to critical systems. In fact, we are currently in the process to define and validate a profile in the automotive domain taking as a base standard the ISO26262 standard [50].

ACKNOWLEDGMENT

This work was partially supported by “Programa de Movilidad del Personal Investigador del Departamento de Educación, Política Lingüística y Cultura del Gobierno Vasco” (MV_2014_1_34).

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