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# Blending Process Assessment and Employees Competencies Assessment in Very Small Entities

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**ABSTRACT.** The ISO/IEC 29110 series aims to provide Very Small Entities (VSEs) with a set of standards based on subsets of existing standards. Process capability determination does not seem suitable for a VSE in terms of return on investment. Our approach proposes to move the viewpoint away from process and to the human resources. We propose a blended assessment model using the ISO/IEC 15504 for the level 1, but based on competency assessment for higher capability levels.

**Keywords:** small entities; process assessment; competency framework.

## 1 INTRODUCTION

Since 2011 the ISO/IEC 29110 [1] series provides Very Small Entities – VSE (up to 25 people) with a set of standards establishing a framework for software life cycle processes and helping VSEs in achieving capability recognition of their processes. A requirement for the Working Group 24 (of which the authors are members) mandated to develop the 29110 series was that processes should be assessed using ISO/IEC 15504 [2] approach.

A meta-analysis [3] about case studies reporting process improvement approaches for 122 SMEs states that the ISO/IEC15504 model was used only in 9% of the reported improvement efforts, which would tend to support that a 15504-based approach for VSE process assessment may not be the most appropriate approach. Accordingly, the first research question addressed in this paper is: How small organizations or projects can use the ISO/IEC 29110 standard to effectively monitor their progress and to evaluate their performance?

Competency frameworks, such as the e-Competences Framework [4] focus on professional skills rather than organizational and technical processes. We propose that such information will be found more relevant by VSEs staff and furthermore that competency assessment helps ICT professionals by developing the right skills and by deploying them to best effect, it will, in time, improve understanding and performing

software processes. Thus we define a second research question: How can we relate VSE process performance with employees' competencies proficiency?

Section 2 overviews background work and section 3 Process Assessment Models. In section 4, we present a Competency Assessment Model for VSEs, and then we conclude the paper.

# 2 BACKGROUND AND RELATED WORK

## 2.1 Standard background

The documents in the ISO/IEC 29110 series are referred to as VSE profiles (organized within Groups) [5] and are based on subsets of appropriate standards elements, which are relevant to the VSE context such as processes and outcomes of ISO/IEC 12207 [6] and products of ISO/IEC 15289 [7].

The Basic Profile describes software development of a single application by a single project team with no special risk or situations factors [1]. The Basic Profile yields a comprehensive set of life cycle processes, activities and tasks, with input and output work products. The starting point for a VSE aiming to establish conformance to a profile is the use a Process Assessment Model, suitable for the purpose of assessing process capability, based on the targeted profile. One result presented in this paper is to formally exhibit the underlying Process Reference Model (PRM) that is contained into the ISO/IEC 29110 Basic Profile documents, and to propose a Process Assessment Model for the capability level 1.

A competency framework is intended to foster the development of skills, either by individuals or organizations. The European e-Competence Framework (http://www.ecompetences.eu/) is a reference framework of 40 ICT competences that can be used and understood by ICT stakeholders [4]. A competence is "*a demonstrated ability to apply knowledge, skills and attitudes to achieving observable results* [8]."

Following the recommended ISO/IEC 15504 approach, a Process Assessment Model (PAM) will expand the Basic Profile PRM by adding the definition and use of assessment indicators process performance indicators and process capability indicators. The latter are, in our opinion, too complex and too far from day-to-day VSE concerns. Our approach proposes to move the viewpoint from process perspective to human resource (i.e. the VSE staff). Job profiles contain many components describing the essential elements of a job and how it should be performed. Jobs profiles provide a bridge between enterprises and individuals, and establish the link between an organization processes and employees' competencies. It is our proposition that VSE employees should be motivated by competencies assessment related to their job profiles. It is also considered that assessing employees' competencies provide a correct indication of the VSE maturity as long as process and competency framework are correctly aligned.

### 2.2 Related Work

A lot of research has been performed on software process assessment for small companies based either on ISO/IEC 15504 [10, 11, 12, 13] or CMMI [14, 15, 16]. Almost all approaches aims to minimize the assessment time and are reducing the number of assessed processes. Several approaches are using process-area interviews (or questionnaires) as the central stage to collect evidences of process achievement. In [17], the authors propose the development of a novel process assessment model for VSEs using the ISO/IEC 29110. The proposed PRM is very similar to ours, expected that base practices are extracted from ISO/IEC 15504-5 and based on the mapping to ISO/IEC 12207 outcomes. They limit the assessment model to process performance indicators, excluding capability levels higher than level 1.

## 3 PROCESS ASSESSMENT MODEL

### 3.1 A Process Reference Model for VSEs

**ISO 12207:2008 and 15504:2006.**

ISO/IEC 12207:2008 Clause 7 describes software-specific processes in terms of Title, Purpose, Outcomes, Activities and Tasks. The ISO/IEC 15504:2006 separates process and capability levels in two dimensions [2]. In the process dimension, individual processes are described in terms of Process Title, Process Purpose, and Process Outcomes as defined in ISO/IEC 12207. In addition to this PRM aligned on the 12207 PRM, the 15504 process dimension provides a set of base practices (BP); a number of input and output work products (WP); and characteristics associated with each work product [2].

**Basic Profile Processes.**

The Basic Profile [5] is made of 2 processes: Project Management (PM) and Software Implementation (SI). Processes are described with: Name; Purpose; Objectives; Input, output, and internal products; Roles involved; Activities list and activities description. Clause 7 contains the specification of the standardized profiles and its conceptual model is represented in Figure 1. Clause 8 establishes the reference between the 29110 elements and the source standards [18] and its conceptual model is also represented in Figure 1.

As pointed out in [17], ISO/IEC 29110-4-1 cannot be considered as a Process Reference Model (PRM) per se, but the ISO/IEC 29110 set of documents is containing all materials required to build a PRM for the Basic Profile. A PRM is defined in ISO/IEC 15504 as "*a model comprising definitions of processes in a life cycle described in terms of process purpose and outcomes, together with an architecture describing the relationships between the processes* [2]." ISO/IEC 29110-4-1 provides the architecture and processes purposes. We only lack of outcomes and we created process outcomes using 12207 process outcomes referenced by each 29110 objective. This appears in Figure 1 with a dotted dependence link between 29110 and 12207 outcomes. The PRM we built is available at http://29110.univ-brest.fr/en.nexus.

### 3.2 A Process Assessment Model for VSEs

**ISO/IEC 15504:2006.**

The capability dimension consists of six capability levels and nine Process Attributes (PA) for levels 1 to 5. A process attribute is "*a measurable characteristic of process capability applicable to any process* [2]."

The 15504 approach indicates that a Process Reference Model lacks of level of detail for conducting consistent and reliable assessments. Therefore, a) the PRM need to be supported with a comprehensive set of indicators of process performance; and b) the capability levels and process attributes need to be supported with a set of indicators of process capability.

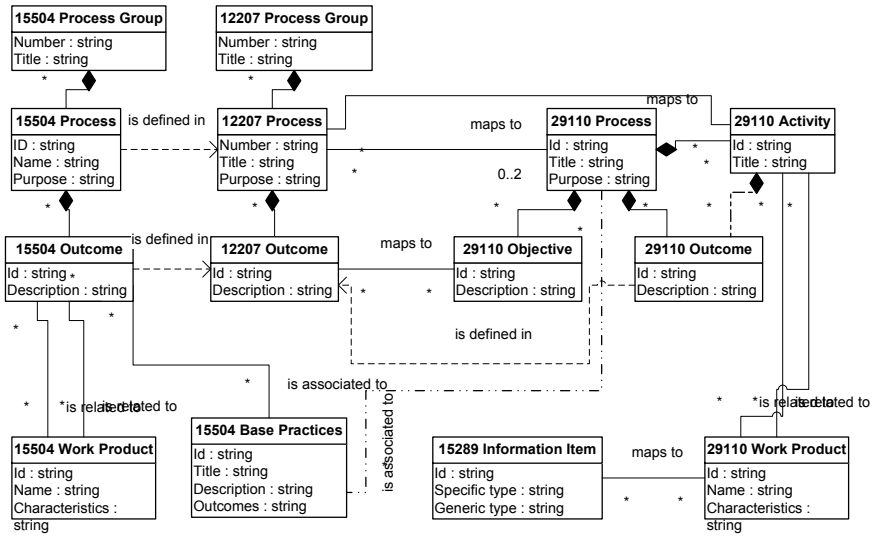


**Fig. 1.** Structure of 15504, 12207, 29110 standards and of their relationships.

A Deployment Package (DP) is a set of artifacts developed to facilitate the implementation of the ISO/IEC 29110 series. DPs are provided, at no cost, by a network of centers to support VSEs. Our research results use the set of available Deployment Packages to provide the set of indicators of process performance. In order to prepare our contribution to an Assessment Model for VSEs (see next section), we present in the left part of Figure 1, the conceptual model of the ISO/IEC 15504 Process assessment, mainly 15504 processes, outcomes, base practices and work products. The ISO/IEC 15504-5 provides an exemplar model for performing process assessments that is based upon and directly compatible with the Process Reference Model in ISO/IEC 12207. References appear in Figure 1 with a dotted dependence link between 15504 and 12207 elements.

**15504 Performance Indicators.**

ISO/IEC 15504 states the result of successful implementation of process assessment: a) information and data that characterize the processes assessed is determined; b) the extent to which the processes achieve the process purpose is determined [2, Part 2].

This extent is derived from the process attributes ratings for an assessed process. The extent of achievement of a process attribute is measured on a scale using values: N Not achieved, 0 to 15 % achievement; P Partially achieved, > 15 % to 50 % achievement; L Largely achieved, > 50 % to 85% achievement; F Fully achieved, > 85 % to 100 % achievement.

Capability Level 0 denotes an incomplete process. Capability Level 1 denotes a performed process. Higher levels denote higher process maturity: the process is managed (Level 2), established (Level 3), predictable (Level 4), optimizing (Level 5).

Performing its business processes is the main concern of a VSE. That means that a VSE's main (and may be the unique one) goal in a Process Assessment is to be assessed at Capability Level 1 for each selected process. Therefore helping a VSE to perform process through a Capability Level 1 assessment will probably retain its attention and raise some investment. The rating of process performance indicators, which apply exclusively to capability level 1, should motivate VSEs. These indicators are Base Practices (BP) and Work Product (WP).

**ISO 29110 Process Attributes.**

Our first research question is asking how small organizations or projects can use the ISO/IEC 29110 standard to effectively monitor their progress and to evaluate their performance. Our answer is to focus on BP and WP indicators.

Specifying Base Practices and Work Products for the Basic Profile is submitted to the problem that ISO/IEC 29110 process granularity is too broad and we will specify BP and WP at the 29110 activity level. In an earlier work [19] about ISO/IEC 29110 Process Assessment Issues, we established the reduced set of ISO/IEC 15504 Processes and Base Practices that are related to 29110 Processes and Objectives thanks to a mapping between ISO 15504 BPs and 29110 processes. The merge of this earlier work and the work presented should be the basis to build an exemplar process assessment model for VSEs. This model shifts the viewpoint from process assessment to activity. Following this point of view, our contribution is to propose in the next section a set of BPs for each ISO/IEC 29110 activities.

**29110 Performances Indicators.**

In Part 5-1-2 [18], each activity is associated with a set of constitutive tasks that shall be considered as Base Practices. 6 Deployment Packages are provided with the Basic Profile. DP 1 [21] covers the whole Project Management Process; DPs 2 to 6 [20, 22, 23, 24, 25] cover all of the activities of Software Implementation Process. We carefully examined DPs 1 to 6, which cover the majority of the Basic Profile activities. Almost none excepted DP Software Design is using the standardized tasks decomposition and almost all – DP Software Design excepted - are providing alternative

activity decomposition with input and output WPs. The analysis is available at http://29110.univ-brest.fr/en.nexus/index.php/AAB

Each corresponding DP provides a task decomposition – although not standardized – and for each task, a step-by-step guideline to perform the task. Formally, the term 'task' should not be used in DPs and we will call 'sub-activity' the elements of the alternative activity decomposition provided in DPs.

Once the 4-level decomposition is established for the Basic Profile, we can map this decomposition with the 15504 Exemplar Process Assessment Model. Thus, sub-activities presented in Table 1, column 2, play an equivalent role than 15504 Base Practices. Hence, within PM and SI processes, each activity will be assessed at Capability Level 1 on the basis of two Process Performance Indicators: Sub-activities and Work Product. This is an answer element to research question 1 - regarding using ISO/IEC 29110 for progress monitoring and performance evaluation - because evidence of performance of the sub-activities, and the presence of work products with their expected work product characteristics, provide objective evidence of the achievement of the purpose of the activities.

**Performing a Basic Profile Assessment.**

The ISO/IEC 15504 distinguishes between two different classes of indicators: indicators of process performance - related to the Base Practices (BP) and Work Products (WP), and indicators of process capability - related to the management practices. BPs and WPs are the heart and the soul of a software lifecycle and the minimal maturity level of a VSE imply to perform a suitable set of BPs and WPs. Management practices relate to the process attributes grouped into capability levels 2-5. Process capability determination seem not suitable from a VSE point of view: the return on investment is too long, the recommendations are highly complex, and process improvement projects require a large investments in terms of budget, timeframe and resources.

A lot of work has been done in relation to tailoring process assessment for VSEs, mainly by reducing the number of processes assessed [26], the number of conceivable capability levels [27], or the burden of the assessment task [16]. A base practice is a work performance that addresses the purpose of a particular process (an activity). The base practices are described at an abstract level, identifying "what" should be done without specifying "how". Consistently performing the base practices associated with a process / activity will help the consistent achievement of its purpose. While DPs are providing a step-by-step guide for each DP, we can use it as a guide to "how" implement the activity. That is another answer element to research question 1 because it provides VSEs with a way of doing activities, motivating them to achieve activities at Capability Level 1.

# 4 COMPETENCY ASSESSMENT MODEL

## 4.1 Overview

This section is intended to examine research question 2 and presents some potential resolving issues. This work proposes an alternative way of assessing capability, profiled from the ISO/IEC 15504 for the capability level 1, but based on competency assessment for higher capability levels. In our opinion, frontier between the VSE – as an organization – maturity and VSE employees' proficiency is thin and porous. VSE strength and weakness are closely related to its staff performance and it may be reasonable to suggest that assessing employees' proficiency will give a good indication of VSE performance so long as the competency assessment framework is closely related to VSE business and needs. Therefore, this is the proposal we put forward for answering to research question 2 and the results proposed in the rest of this paper need to be validated through several studies.

## 4.2 Reference models

**Models Architecture.**

The European e-Competence Framework is based on a four-dimensional approach, based on competence areas (dimension 1) and competences (dimension 2). Dimension 3 provides level assignments that are appropriate to each competence. Dimension 4 provides short sample of knowledge and skills.

Dimension 1 is composed of 5 e-Competence areas that reflect the ICT Business process and its main sub-processes, from a broad perspective. Dimension 1 is mapped to 12207 Process Group, to 15504 Process Group and to 29110 Processes (because they have a very broad scope). Dimension 2 identifies and describes a set of key e-Competences for each area. We established the mapping between e-Competences and Life Cycle Processes by comparing the e-Competences titles, generic descriptions and skill examples with the Processes titles, purposes and activities and tasks (12207) or Base Practices (15504). We reduced the e-CF to the software perspective because it is the scope of the ISO/IEC 12207 standard. Dimension 4 is populated with samples of knowledge and skills related to e-Competences in dimension 2. They are provided to add value and context and are not intended to be exhaustive. Conversely, Base Practices are supporting the process and are exhaustive. Accordingly Base Practices and sub-activities cannot be mapped with skills but all these concepts form the third level of the reference models. In next sections, we will see that an exhaustive list of skills within a role is essential to competency assessment.

**Activities and e-Competences.**

There are different views of what the ICT profession is and no common agreement regarding a shared body of knowledge, especially for VSEs. The purpose of the ISO/IEC 29110 Basic Profile is to provide the minimal subset of ISO/IEC 12207 processes, thus we may use this to obtain a minimal subset of e-Competences for a VSE. The complete mapping between e-Competences and ISO/IEC 12207 processes pro-

vides us with a starting point upon we established a mapping between ISO/IEC 29110 activities and e-Competences. We produced the mapping between e-Competences and ISO/IEC 29110 activities by carefully comparing the e-Competences titles and generic descriptions with the activities descriptions. To clarify ambiguities, it was necessary to compare the scope of skills examples in Dimension 4 with tasks lists of activities and the corresponding DP materials. The mapping is at http://29110.univ-brest.fr/nexus/index.php/E-C_Mapping.

### 4.3 Using the e-CF for ISO/IEC 29110

**Rationale.**

In section 2.1, we stated that process capability indicators are too far from day-to-day VSE concerns and we proposed to focus on job profiles. Job profiles or roles "*add to job descriptions by including additional job related components such as mission, main tasks, accountability, requested deliverables, Key Performance Indicator's etc. In this context a job profile provides a comprehensive description written and formal of a job* [9]". Job profiles establish the link between an organization processes and employees' competencies. Our proposition is that VSE employees should be motivated by competencies assessment and will accept the long return of investment, the high complexity and the required commitment and effort because they will be the main beneficiaries of this assessment.

**Roles and job profiles.**

Roles are defined inside ISO/IEC 29110 activities description [18], as function to be performed by project team members. Different roles are: PM Project Manager, TL Technical Leader, AN Analyst, DES Designer, and PR Programmer. A single person may play several roles and several persons may assume one role. Roles competencies are drafted [18]. Thus, it was straightforward to establish the pivotal place of roles between software activities and competences, http://29110.univ-brest.fr/en.nexus/index.php/Roles_and_e-C.

| | | | | |
|---|---|---|---|---|
| | | | | |

**Table 1.** Profiles based on e-CF 3.0

| ICT Profile Title | e-Competences 3.0 | Level |
|---|---|---|
| Project Manager (PM) | A.4. Product / Service Planning | 4 |
| | E.2. Project and Portfolio Management | 4 |
| | E.3. Risk Management | 4 |
| | E.4. Relationship Management | 3 |
| | E.7 Business Change Management | 3 |
| System Architect (TL) | A.5. Architecture Design | 4 |
| | A.7. Technology Watching | 4-5 |

| ICT Profile Title | e-Competences 3.0 | Level |
|---|---|---|
| | B.1. Design and Development | 4-5 |
| | B.2. System Integration | 4 |
| System Analyst (AN / DES) | A.6. Application Design | 3 |
| | E.5. Process Improvement | 3-4 |
| | B.1. Design and Development | 3-4 |
| Developer (PR) | B.1. Design and Development | 3 |
| | B.2. System Integration | 2 |
| | B.3. Testing | 2 |
| | B.5. Documentation production | 3 |
| | C.4. Problem Management | 3 |

As a response to the huge number of ICT profile frameworks and profile descriptions, the CEN Workshop Agreement "European ICT Profile" defines a number of representative ICT profiles covering the full ICT business. Each profile defines a mission statement, a list of required e-competences to carry the mission, a list of deliverables, a list of tasks and some Key Performance Indicators (KPI). There are four ICT profiles that correspond to the five 29110 roles. The associated e-competences with the required proficiency level are presented in Table 1.

**Proficiency Level.**

Proficiency can be defined as a level of being capable or proficient in a specific knowledge, skill domain expertise or competence [8] and is related to job performance. Proficiency indicates a degree of mastery that allows an individual to function independently in her/his job. In the e-CF, proficiency levels are described along three facets [8]: Autonomy ranging between “Responding to instructions” and “Making personal choices”; Context complexity ranging between “Structured-Predictable situations” and “Unpredictable-Unstructured situations”; Behavior ranging between “Ability to apply” and “Ability to conceive”.

**Completing the e-CF Dimension 4.**

Roles competencies shall be completed with their required proficiency level. Once an e-Competence required within a role, it is possible to establish an exhaustive list of knowledge and skills. However, a detailed description of required skills is missing in the e-CF but is needed to be able to assess the proficiency level. Establishing Basic Profile roles and specializing required e-Competences knowledge and skills is an exhaustive work that will be proposed to the WG24, and may provide a new part of ISO/IEC 29110 for each profile, dedicated to roles and competencies.

Our pragmatic approach is to define e-Competences skills within a role, but a useful synthesis will be to gather all knowledge and skills related to the same e-Competence through the different Basic Profile roles, in order to have at one’s disposal a centralized definition of each e-Competence related to the Basic Profile.

### 4.4 Performing a proficiency level assessment

**Rationale.**

While proficiency assessment is performed within a role, it allows the VSE to select the adequate skills from the whole framework. For instance, if programmers do not hold the test process, B.3 Testing will be reduced to skills B.3.6 and B.3.7.

Proficiency levels are related to job performance and as mentioned in previous section proficiency levels are described along three facets: Autonomy, Context complexity, and Behavior. Despite the detailed skills added to e-competences, the scope is still very broad and we need to go further in details to understand the proficiency level and our proposal is to add outcomes to each skill of each e-competences. Outcomes are worded in operational terms.

**Competence reference framework.**

Table 2 presents excerpts of the framework for the skills of e-Competence B.1. Design and Development. Each skill has a purpose and a set of outcomes, expressed in term of "be able to know" or "to be able to do".

**Table 2.** e-Competence B.1 outcomes

| **B.1. Design and development** |
|---|
| ***B.1.3. Establish a detailed design, including a database schema*** |
| • To detail SW components and interfaces<br>• To detail and update the SW design document<br>• To normalize a database schema and to understand the normalization impact on queries performances<br>• To perform human-centred design activities |
| ***B.1.5. Develop batch modules interacting with the database*** |
| • To understand the difference between the SQL set model and a procedural language model<br>• To grasp procedural constructs and their execution conditions<br>• To master the development of procedural constructs and the exception handling mechanism<br>• To develop and perform unit testing, including a regression test strategy<br>• To manage the backup, storage, archiving, handling and delivery of configured items |

**Rating outcomes.**

Each skill is described as a set of cohesive outcomes. Our rating scheme is based on the assessment of each VSE employee about her/his achievement of outcomes. We use the N-P-L-F scale of ISO/IEC 15504. When an employee states that an outcome is Largely and Fully achieved, he/she is supposed to accompany the rating by objective evidence, generally a product that he/she produced or contributed to. When all outcomes of a general goal are rated at L or F, the skill should be rated at the same rating.

**Rating proficiency level.**

When all skills of an e-competence are rated at L or F, the e-competence is considered to be achieved, but the proficiency level needs to be established. The e-CF uses a 5-point ordinal scale from e-1 to e-5 (e-5 is rarely used). Due to an alignment with European Community directives, level 2 is divided in 2 sub-levels: 2-A and 2-B.

The hypothesis is made that VSE employees will commit in a self-assessment. As mentioned in this section overview, the hypothesis is also made that assessing employees' competencies provide a correct indication of the VSE maturity as long as process and competency framework are correctly aligned. Challenges of this approach are related to provide a straightforward competency framework with a lightweight competency assessment approach and a precise and correct alignment between process models and competency framework.

### 4.5 A case study

We trialed this approach through the PR role mobilizing 7 skills: B.1.2 Preliminary design, B.1.3 Detailed design, B.1.4 Develop SQL scripts, B.1.5 Develop batch modules, B.3.6 Conduct tests, B.3.7 Report tests, B.5.4 Documentation. A 4-week vocational education training session on information system development under the ISO/IEC 29110 Basic Profile has been used to measure the attendees' proficiency level and to relate it to 29110 processes used in teamwork. A total 21 students in the 2nd year of an MSc programme in Information Technology participated in a 4 week training exercise building small an information system. 36 hours of lectures and practical labs were performed along the skills: B.1.2, B.1.3, B.1.4, B.1.5, B.3.6, B.3.7, and B.5.4. The remaining time is devoted to a capstone project performed by teams of 3-4 attendees.

For each skill, each attendee self-assessed their achievement of outcomes on the N-P-L-F scale. In order to get averages, numerical values are associated with N-P-L-F values - don't know: 0%, N: 15%, P: 50%, L: 85%, F: 100%. A skill is valued with the average of its outcomes values. We gathered values for each team, where each team's general goal value is the average of its members' values. Table 3 presents the assessment for the 6 teams and the whole set of attendees; the last line is the overall average, and represents teams' self-esteem. Team average is roughly the same, except for team B that is probably over-estimating itself.

**Table 3.** Teams' self-assessment of PR role.

| Skill | A | B | C | D | E | F | All |
|---|---|---|---|---|---|---|---|
| B.1.2 | 0,68 | 0,69 | 0,78 | 0,81 | 0,85 | 0,69 | 0,75 |
| B.1.3 | 0,51 | 0,69 | 0,72 | 0,56 | 0,43 | 0,63 | 0,58 |
| B.1.4 | 0,37 | 0,63 | 0,42 | 0,48 | 0,42 | 0,46 | 0,47 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| B.1.5 | 0,39 | 0,68 | 0,20 | 0,29 | 0,41 | 0,34 | 0,40 |
| B.3.6 | 0,22 | 0,59 | 0,15 | 0,15 | 0,24 | 0,24 | 0,28 |
| B.3.7 | 0,22 | 0,29 | 0,38 | 0,27 | 0,33 | 0,33 | 0,30 |
| B.5.4 | 0,33 | 0,29 | 0,15 | 0,62 | 0,20 | 0,24 | 0,30 |
| *Team avg.* | *0,31* | *0,49* | *0,32* | *0,34* | *0,32* | *0,36* | *0,36* |

During the training session, we collected individual observations from attendees regarding autonomy, context complexity and behavior. The autonomy of each attendee was the easiest thing to observe. Behavior observations were mostly performed while reviewing the work products issued by teams; hence it was more difficult to assign it individually. Context complexity was not relevant in this case, because all teams are developing the same software from the same requirements specification. Nevertheless, using the self-assessment, and our observations, we assessed each attendee's skill at a proficiency level 1, 2-A or 2-B. Table 4 presents this proficiency assessment with (x,y,z) where x is the number of team members at level 1; y at level 2-A and z at level 2-B.

**Table 4.** Teams' proficiency assessment.

| **Skill** | **A** | **B** | **C** | **D** | **E** | **F** |
|---|---|---|---|---|---|---|
| B.1.2 | (0,3,0) | (0,4,0) | (0,2,1) | (0,1,2) | (0,2,2) | (0,1,3) |
| B.1.3 | (2,1,0) | (2,2,0) | (0,2,1) | (0,3,0) | (3,1,0) | (1,2,1) |
| B.1.4 | (3,0,0) | (1,2,1) | (2,1,0) | (1,2,0) | (3,1,0) | (2,2,0) |
| B.1.5 | (3,0,0) | (1,2,1) | (3,0,0) | (2,1,0) | (3,1,0) | (1,2,1) |
| B.3.6 | (3,0,0) | (4,0,0) | (0,3,0) | (0,3,0) | (1,3,0) | (1,3,0) |
| B.3.7 | (2,1,0) | (2,2,0) | (0,3,0) | (0,3,0) | (0,3,1) | (0,3,1) |
| B.5.4 | (3,0,0) | (4,0,0) | (2,1,0) | (0,2,1) | (2,1,1) | (2,2,0) |

In relation to the capstone project, the life cycle processes were extracted from ISO/IEC 29110. The schedule is roughly: one week for architectural design (including the problem understanding), one week for detailed design, two weeks of development (including end-user documentation), and one day for qualifying the software. Hence, teams are concerned with three ISO/IEC 29110 activities: Design, Construction, Integration and Tests. We assessed each team's activity capability level using the standard ISO/IEC 15504 scheme. Capability level 1 is measured with the PA 1.1 Process performance attribute. Capability level 2 is measured with the PA 2.1 Performance management attribute and the PA 2.2 Work product management attribute. Table 5 presents the assessment results.

**Table 5.** Teams' processes assessment.

| | **A** | **B** | **C** | **D** | **E** | **F** |
|---|---|---|---|---|---|---|
| *SI.3 SW Architectural and Detailed Design* | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| PA 2.1 | N | N | N | P | P | **L** |
| PA 2.2 | P | P | P | **L** | **L** | **L** |
| PA 1.1 | P | P | **L** | **L** | **F** | **L** |
| *SI.4 SW Construction* | | | | | | |
| PA 2.1 | N | N | N | P | P | P |
| PA 2.2 | P | P | P | P | P | P |
| PA 1.1 | P | **L** | **L** | **L** | **F** | **F** |
| *SI.5 SW Integration and Tests* | | | | | | |
| PA 2.1 | N | N | N | P | P | **L** |
| PA 2.2 | P | P | **L** | **L** | **L** | **L** |
| PA 1.1 | P | **L** | **L** | **L** | **F** | **F** |

We may correlate the capability level achieved by a team (Table 4) with the team proficiency level (Table 5). The correlation is working well for the SI.3 Design activity, except for team B. The correlation is not working for all teams with the SI.4 Construction activity that is not surprising because development is probably the most unpredictable activity. The correlation is working roughly for the SI.5 Integration activity, but we suspect that B.3.6 and B.3.7 form only a part of the set of skills required to perform the Integration tasks.

This case study is still encouraging; however three issues require further work. To reduce the complexity, we worked within a unique role but the association between activities and skills should work through the different Basic Profile roles. The second issue is related to the proficiency level assessment that has to be more objectively defined. The third issue is concerned with the graduation of different skills that are not of equal importance for a given activity and we should probably weight the skills with a coefficient. Resolving these issues requires us to build the complete model and to validate it through several pilot studies in VSEs.

# 5 PERSPECTIVES AND CONCLUSION

The next major step will be to develop the approach for all ISO/IEC 29110 roles and validate each role through a series of pilot projects in VSEs.

The aim of our research was to contribute to an exemplar Process Assessment Model (PAM) suitable for VSEs, related to a Process Reference Model (PRM) of the Basic Profile. The exemplar PAM expands the Basic Profile PRM by adding the definition and use of assessment indicators. We proposed to add an additional level to the ISO/IEC 29110 by dividing each activity in sub-activity playing a role similar to ISO/IEC 15504 Base Practices. These sub-activities were extracted of the different Deployment Package provided by a network of VSE support centers. Sub-activities and Work Products will be used as process performance indicators and permit a VSE to be assessed at Capability Level 1.

For higher capability levels, we proposed to replace process capability determination with competency proficiency level assessment. Proficiency indicates a degree of mastery that allows an individual to function independently in the performance of a specific knowledge application, skill domain, expertise or competence.

We proposed to add to the ISO/IEC 29110 roles definition a set of e-Competences mobilized with their required proficiency level. Then we established an exhaustive list of skills for each e-Competence and we associated a set of outcomes to each skill of each e-Competence. Self-rating is devoted to VSE employees and proficiency level determination will be performed by external assessors. We made the proposal that as main beneficiaries of competency assessment, they will accept to self-assess each outcome on a classical N-P-L-F scale, conducting to rate each skill. Through an external assessment, VSE employees will contribute to establish a proficiency level for each e-Competence that will replace process capability determination. It is assumed that it provides an indication of the VSE organizational maturity, but this has to be proven through several case studies.

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