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# A Compliance Analysis of Agile Methodologies with the ISO/IEC 29110 Project Management Process

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**Abstract**

Software process standards (e.g. ISO/IEC 12207, ISO/IEC 15504) and models (e.g. CMMI) provide a set of best practices and guidelines for improving the quality of the software process and products resulting from that process. However, they do not prescribe a particular software development methodology (i.e. RUP, MSF), and thus software development teams face a compliance problem between the selected development methodology and a pursued particular standard or model. In this research, the particular issue of compliance of Agile Software Development Methodologies (SCRUM, XP, and UPEDU) and the new ISO/IEC 29110 standard is studied. Because the new standard is focused on the software process in very small software development companies or small software project teams in the range from 1 to 25 people, and the Agile Software Development Methodologies (ASDMs) are primarily for same targets, this study is important. The ISO/IEC 29110 standard contains two processes: Project Management and Software Implementation. This study is focused on the first process. The main findings indicate that the UPEDU and SCRUM methodologies present and high compliance level with the ISO/IEC 29110 Project Management process, while XP has a moderate level. Thus, software developer teams interested in achieving compliance with the ISO/IEC 29110 Project Management process can count with two ASDMs. However, a full compliance study (with both Project Management and Software Implementation) is still missing.


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## 1. Introduction

Software process standards (like ISO/IEC 12207, ISO/IEC 15504, and ISO/IEC 90003) and models (like CMMI) have been developed by international associations for helping to software development organizations to meet the current demands for quality process and software product improvements [1, 2]. According to [3; pp. 373] "*Whilst the models are considered as de facto standards (not a legal mandatory use) and the standards as de jure (legal mandatory use when a country or business sector agrees use it), both help the organizations to improve the quality of their internal processes and to align them with international practices*".

Software process standards and models provide also a map of the best current management, engineering and organizational practices for performing high-quality processes. A standard is a document "*established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context*" [2]. A software process model can be defined as a *structured collection of practices that describe the characteristics of effective processes* [4]. These software process standards and models are important for software development organizations because their implementation has generated benefits reported in the literature [5, 6] such as: cost reduction, fit to schedule, better quality, and better customer satisfaction. Furthermore, modern business international practices demands that business organizations (including software development organizations) provide evidences on the quality, consistency and standardization of their used processes for delivering their products and services. Thus, business organizations (including software development ones) are highly interested in implementing and using a software process model or standard.

However, according to [2] these software process standards (and models also) "*were not written for small projects, small development organizations, or companies with between 1 and 25 employees, and are consequently difficult to apply in such settings*". Thus, despite of the very small entities (business or teams) represents a high percentage of software business in the world [7], these organizations suffer the negative situation of unsuitable standards or models, and consequently is difficult to apply them in such settings [8, 9]. For addressing such a problematic, a new ISO/IEC 29110 software process standard has been recently released specifically for very small entities [2]. The ISO/IEC 29110 standard is focused on the software process conducted in small software development companies or small software project teams in the range from 1 to 25 people.

Furthermore, while these schemes (models and standards) provide benefits by using them, they do not prescribe a particular software development methodology (such as RUP or MSF [10]), and thus software development teams – from large, medium, small or very small organization - face a compliance problem of what development methodology to use with any particular standard or model. This compliance problem between process standards or models with software development methodologies has been studied previously [11, 12, 13, 14, 15, 16] with the aim to help to organizations in achieving a satisfactory implementation and certification of the selected software process standard or model.

In this research, we address the particular compliance problem of three main Agile Software Development Methodologies (SCRUM [18], XP [19], and UPEDU [20, 21]) with the recently released ISO/IEC 29110 standard. A primary motivation for this is that the new released ISO/IEC 29110 standard is focused on the software process in very small software development companies or small software project teams in the range from 1 to 25 people, and the Agile Software Development Methodologies (ASDMs) are primarily targeted at small and very small organizations or teams [22]. The ISO/IEC 29110 standard contains two processes: Project Management and Software Implementation [9]. We focused this study on the first process. Project Management process is considered a requisite for conducting a satisfactory engineering Software Implementation process [22, 23]. Furthermore, Project Management process is also considered highly relevant in other software process models and standards like CMMI and ISO/IEC 12207. The remainder of this article continues as follows: in the section 2 we report the research goals, questions and methodology; in the section 3 we review the theoretical basis on IDEF0 (the used conceptual tool for

describing and comparing processes) and the ISO/IEC 29110 standard; in the section 4 we report the compliance alysis of these three ASDMs with the Project Management process of the ISO/IEC 29110 standard. Finally, we report the conclusions, recommendations for further research and the limitations of this study.

## 2. Research Goals, Questions and Methodology

This research pursues the main research goal of assessing a compliance level, in an ordinal scale of three values (low, moderate, high) of three main Agile Software Development methodologies (XCRUM, XP, and UPEDU) with the ISO/IEC 29110 Project Management (PM) process (its Entry Profile version). The research questions are the following: RQ.1 Can the IDEF0 conceptual tool be used for supporting the compliance assessment of the three ASDMs PM processes with the ISO/IEC 29110 PM process? RQ.2 What is the qualitative compliance level of the PM processes conducted in SCRUM, XP and UPEDU regarding the PM process proposed in the ISO/IEC 29110 standard (Entry Profile)? RQ.3 What are the initial general implications of the fulfillment or lack of compliance?

For answering them, we use an Evaluative-Interpretative research approach rooted in a Conceptual Analysis methodology [24, 25]. We perform (adapted from [25]) the following tasks: (i) Knowledge gap identification, (ii) Methodological knowledge assessment, (iii) Conceptual Analysis, and (iv) Conceptual Synthesis. In the first task (i) we formulate the research goal, questions for the identified knowledge gap, as well, it is established its relevance. In the second task (ii) we plan the required materials to be collected and analyzed, as well as the conceptual analysis tool. In this research the materials were identified as the official documents published for the ASDMs SCRUM, XP and UPEDU, complemented with main literature on them. The conceptual analysis tool proposed was IDEF0 [26]. IDEF0 is a well-structured conceptual tool used for describing and improving processes [26, 27]. Other compliance studies [11, 12, 13, 14, 15, 16] demanded that researchers elaborate the structure of the compliance framework, or conduct comparisons between among process described in different abstractions levels. In contrast, the IDEF0 provides the benefits of using a well-structured comparison process scheme composed by inputs, outputs, mechanisms and controls, as well as a well-defined top-bottom level abstraction decomposition method. Thus, IDEF0 has been widely used for modeling process in diverse domains such as systems engineering [28], industrial engineering [29], business process management [30] and software engineering [31]. In the third task (iii) the main author generated the IDEF0 diagrams (in two levels) for the PM processes conducted in the ISO/IEC 29110 (Entry Profile), and the three ASDMs SCRUM, XP and UPEDU. These IDEF0 diagrams were reviewed by second and third authors. After an iterative review process for minor changes, final IDEF0 diagrams were ended. Based on these diagrams, and textual descriptions, the main author elaborated three main assessment tables on the activities, roles and artifacts prescribed by the ISO/IEC 29110 PM process regarding the compliance level for each item (activity, role or artifact) reached by each ASDM. The used assessment compliance ordinal scale had three levels: low (when the analyzed item is not existent or weakly reported in the ASDM), moderate (when the analyzed item is covered by the ASDM but partially as it is suggested by the ISO/IEC 29110 standard), and high (when the analyzed item is satisfactory reported in the ASDM as the ISO/IEC 29110 standard prescribes, besides it can be reported with a different nomenclature). A final overall assessment table was also generated by the first author by using the assessment from the previous three tables. The four compliance assessment tables were also reviewed by the second and third authors, and minor changes were conducted. Finally, in the fourth task (iv), all authors elaborated the synthesis of results (main findings, theoretical and practitioner's contributions, and limitations).

## 3. Theoretical Background

### *3.1. The IDEF0 Conceptual Tool*

IDEF0 (Definition of Integration Modeling Function) describes a language (semantics and syntax) and a protocol (rules and technical procedures) to develop well-structured graphical representations on the functions for existent or planned systems [26, 27]. A system in this context can be a physical product, an organization, or a process. In an IDEF0 diagram, the core element is a block which represents a process with four categories of incoming (top, left, bottom) and outgoing (right) links. Top links correspond to fluxes of CONTROL or CONSTRAINTS (informational fluxes which establish limits, rules and goals for the process). Left links correspond to fluxes of INPUTS. Bottom

links correspond to MECHANISMS (human agents, tools and machines required for executing the process). Right links correspond to fluxes of OUTPUTS. The Figure 1 illustrates a general IDEF0 diagram in side (a), and a decomposition view of an IDEF0 diagram in side (b).

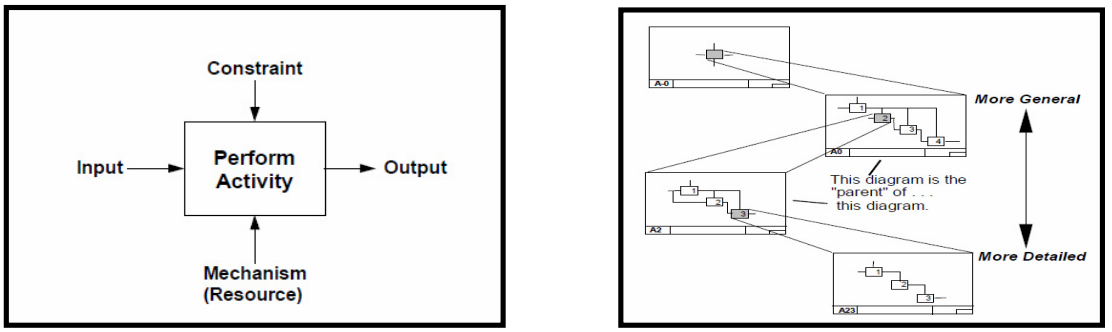


Fig. 1. (a) IDEF0 Diagram; (b) IDEF0 Decomposition View.

### *3.2. The ISO/IEC 29110 Standard*

The ISO/IEC 29110 Software Process Lifecycle standard for VSE (Very Small Entities) provides a lightweight process model developed for organizations classified as very small entities (business organizations or development teams from 1 to 25 people) [32]. ISO/IEC 29110 provides a standard according to the characteristics and needs of VSEs. The ISO/IEC 29110 has two main categories of processes: Project Management (PM) and Software Implementation (SI) [33, 34, 35]. The main features of these two sides are as follows:

• **Project Management** aims *to establish and carry out the tasks of the software implementation, which will fulfill the objectives of the project according to quality, time and expected costs*. PM includes four activities: planning, control, execution and closure [33, 34, 35].

• **Software Implementation** aims *to systematically analyze, design, construction, integration and testing of software products processed according to specified requirements*. SI includes six activities: initiation, analysis, design, construction, tests and delivery [33, 34, 35].

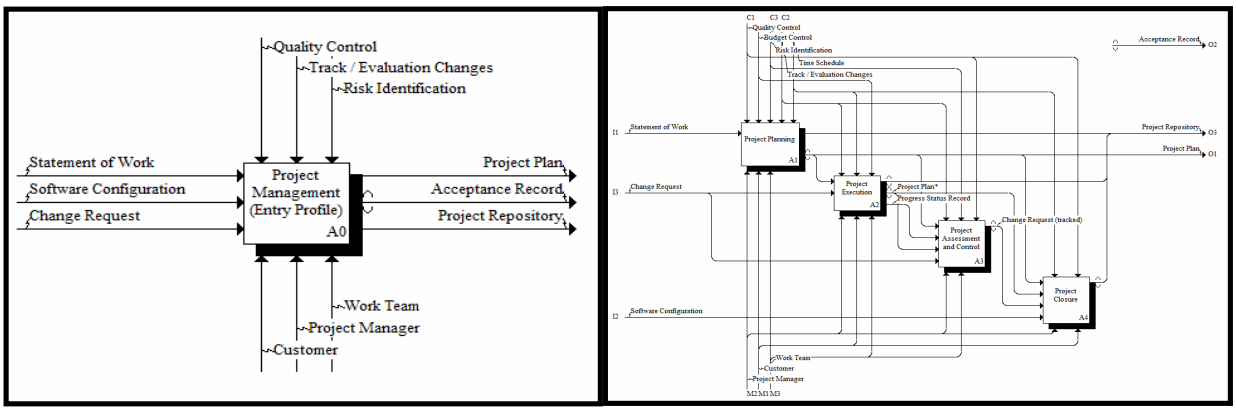


Fig. 2. (a) IDEF0 Top View of the ISO/IEC 29110 PM Process; (b) IDEF0 First Detailed View of the ISO/IEC 29110 PM Process

A PM process (Entry Profile) can be analyzed by using IDEF0 diagrams as illustrated in Figure 2 . The side (a) presents the top IDEF0 diagram of the PM process in ISO/IEC 29110. The side (b) presents the next detailed level, where the four activities of Project Planning, Project Execution, Project Assessment and Control, and Project Closure are illustrated. In Figure 2, we can identify three main INPUTS (statement of work, software configuration, and change requests), three OUTPUTs (project plan, acceptance records, and project repository), three CONTROLS (quality control, track/evaluation changes, and risk identifications), and three MECHANISMS (customer, project manager, and work team). Hence, the IDEF0 descriptions of the three ASDMs (SCRUM, XP, and UPEDU) are expected to fulfill direct or partially this PM process structure of inputs, outputs, controls and mechanisms.

## 4. Compliance Analysis of Agile Software Development Methodologies with the ISO/IEC 29110 Standard

The compliance analysis was conducted on three particular categories of items: roles, activities and artifacts. The IDEF0 diagrams elaborated for the ISO/IEC 29110 PM and the three ASDMs PMs helped for conducting a well-structured comparison with similar abstraction levels. Roles were identified through the MECHANISMS IDEF0 links, activities through the IDEF0 core blocks, and artifacts through the INPUT and OUTPUTS IDEF0 links. The Table 1 shows the roles used in ISO/IEC 29110. We have evaluated the existence of these roles against the reported roles in SCRUM, UPEDU and XP roles respectively. The scale of high, moderate and low compliance level is represented by boxes with a color scale of black, gray and white color respectively. For IDEF0 diagrams the roles are considered as MECHANISMS. According with the ISO/IEC 29110 standard, we consider only three core roles: customer, project manager and work team.

Table 1. Role Compliance among the ISO/IEC 29110 and the ASDMs

| | ROLES | | |
|---|---|---|---|
| ISO/IEC 29110 | Customer | Project Manager | Work Team |
| SCRUM | ■ | ■ | ■ |
| UPEDU | ▫ | ■ | ■ |
| XP | ■ | ▫ | ■ |

- *Customer.* SCRUM and XP have a role with the same name and characteristics that the ISO/IEC 29110 standard. However, customer in PM of UPEDU is not considered. PM of UPEDU has a generic stakeholder role (similar role) and the values for this role are: customer, user, investor, shareholder, production manager, buyer, designer, tester, and documentation writer.

- *Project Manager*. This role is responsible for the management and verification of all the activities of the project. This role is indicated like “Scrum Master” in SCRUM, but in XP this role could be “XP Coach”, “XP Tracker” or “XP Administrator” (the role is not clear for this methodology). Finally, in UPEDU this role has the same name than the used in the ISO/IEC 29110 standard.

- *Work Team*. It consists in all the roles involved in the SI and PM activities.

In the aspect of roles we can observe that SCRUM has a high compliance in comparison with the ISO/IEC 29110 standard. Meanwhile, UPEDU and XP have a moderated overall compliance and XP. For this research, we considered three roles because they are described in the official documents of the ISO/IEC 29110 standard. We can conclude that SCRUM has a good organization in the approach of roles and it satisfies many statements in the ISO/IEC 29110 standard in comparison with UPEDU or XP.

Table 2 shows the compliance evaluation regarding the main activities of the ISO/IEC 29110 standard vs SCRUM, UPEDU and XP. A similar color scale is used. For this analysis we have identified 18 main tasks grouped in four types of activities. UPEDU shows an overall high compliance with these categories. This can be a natural status because UPEDU is derived from a disciplined-based methodology as RUP. After this, SCRUM has a good behavior but it lacks some details in activities as *Update Project Repository* and *Formalize the documents for finishing the project*. XP has some elements in certain categories that must be enhanced for achieving this

compliance to the ISO/IEC 29110 standard. The XP shortcomings relate to improved clarity and organization on the utilization of their core activities. In conclusion, SCRUM and XP are more famous agile methodologies than UPEDU, but we have found that UPEDU shows a more relevant behavior in aspects for PM process posed by the ISO/IEC 29110 standard than the other two ASDMs.

Table 2. Activity Compliance among the ISO/IEC 29110 and the ASDMs

| | Project Planning | | | | | | | | | | | Project Execution | | Project Assessment and Control | | | Project Closure | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISO/IEC 29110 | Review the Statement of Work | Identify the specific tasks… | Establish the Estimated Duration to perform each task. | Identify and document the resources | Establish the Composition of Work Team | Assign estimated start and completion dates.. | Calculate and document the project Estimated Effort and | Identify and document the risks …. | Generate the Project Plan | Review and accept appropriate of the Project Plan. | Establish the project repository. | Monitor and record status… | Conduct meetings with customer.. | Evaluate project progress… | Evaluate and Track… | Establish actions to correct deviations… | Formalize the completion of the project… | Update Project Repository |
| SCRUM | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | □ | ■ | ■ | ■ | ■ | ■ | ▒ | □ |
| UPEDU | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ▒ | ■ |
| XP | ■ | ■ | ▒ | ■ | ■ | ▒ | ▒ | ■ | ■ | ■ | □ | ■ | ■ | ■ | ■ | ■ | ■ | □ |

The table 3 shows the 8 artifacts used in ISO/IEC 29110 standard, which are: Statement of Work, Project Repository, Meeting Record, Progress Status Record, Project Plan, Change Request, Software Configuration and Acceptance Record. For this assessment, we use the same ordinal scale of three values. According to [21], artifacts "*are either final or intermediate work products that are produced and used during a project. Artifacts are used to capture and convey project information*". The artifacts are very important for measuring the project advance and for managing the performance of the different stages of each method. For instance, in the Table 3 we can observe that the Project Repository artifact was not found explicitly in the XP method, because this methodology does not report a place to contain the work products and deliveries. Also, the presence of software configuration activity in SCRUM and XP are medium (it is not explicitly reported). Finally, the artifact of Acceptance Record is critical when the product is completed or when a product needs to be analyzed, but it artifact has a low importance in XP and SCRUM. In XP methodology the communication factor is very important even in informal projects, while that the written documents are not critical.

In conclusion for this compliance category of artifacts, UPEDU was found with a high compliance level. The official 8 artifacts reported in the ISO/IEC 29110 standard are very similar in essence, with the artifacts reported in UPEDU. In second place we can locate to SCRUM with some aspects required to be improved as the artifacts of Project Repository, Software Configuration and Acceptance Record. Finally, XP has some lacks (low level assessments) in the same categories as SCRUM. XP needs more clear explanations and organization for its artifacts.

Table 3. Artifact Compliance among the ISO/IEC 29110 and the ASDMs

| ISO/IEC 29110 | Statement of Work | Project Repository | Meeting Record | Progress Status Record | Project Plan | Change Request | Software Configuration | Acceptance Record |
|---|---|---|---|---|---|---|---|---|
| SCRUM | ■ | ▒ | ■ | ■ | ■ | ■ | ▒ | ▒ |
| UPEDU | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| XP | ■ | □ | ■ | ■ | ■ | ■ | ▒ | □ |

The Table 4 shows the overall compliance summarization by integrating the three analyzed categories of activities, artifacts and roles. We have assigned the values from 1 to 3 respectively for low, moderate and high assessments. The Table 4 reports the average scores assigned for each ASDM. Thus, the values close to 3 in the "average" column, imply a high compliance level with the PM process of the ISO/IEC 29110 standard.

According with the above results we can interpret that the PM process of UPEDU is the closer to the PM process of the ISO/IEC 29110 standard based on the three categories of roles, activities and artifacts than the other two ASDMs. SCRUM is reported as the second methodology in compliance and the third place is for XP. With these results, we consider that next logical steps of this research are the design of an enhanced PM process for these three ASDMs in order to achieve a full compliance with the ISO/IEC 29110 standard. With it, ASDMs practitioners will count with a software development process more aligned jointly with agile and best standard practices. This achievement must be a motivation for VSEs interested in increasing their opportunities for gaining software development contracts that demand the certification or compliance with an ISO standard.

Table 4. Overall Evaluation among the ISO/IEC 29110 and the Agile Methodologies.

| | Activities | Artifacts | Roles | Average |
|---|---|---|---|---|
| SCRUM | 2.72 | 2.65 | 3.00 | **2.79** |
| UPEDU | 2.94 | 3.00 | 2.66 | **2.86** |
| XP | 2.61 | 2.37 | 2.66 | **2.54** |

## 5. Conclusions

This paper has addressed the compliance issues of the PM process of three main Agile Software Development Methodologies (SCRUM, XP, and UPEDU) with the recently released ISO/IEC 29110 standard. The ISO/IEC 29110 standard is focused on the software processes for very small software development companies which is also the main target audience for agile methods. In specific, this research addressed three research questions. RQ.1 was established as: Can the IDEF0 conceptual tool be used for supporting the compliance assessment of the three ASDMs PM processes with the ISO/IEC 29110 PM process? Based on the complexity of the analyzed materials (different levels of descriptions; different several structures of phases, activities, tasks, roles, artifacts; and different nomenclatures) it can supported that IDEF0 diagrams are useful analysis tools for describing and comparing software processes.

In turn, RQ.2 and RQ.3 were established respectively as: What is the qualitative compliance level of the PM processes conducted in SCRUM, XP and UPEDU regarding the PM process proposed in the ISO/IEC 29110 standard (Entry Profile)? , RQ.3 What are the initial general implications of the fulfillment or lack of compliance? Regarding the qualitative compliance level of the PM processes conducted in SCRUM, XP and UPEDU regarding the PM process proposed in the ISO/IEC 29110 standard (Entry Profile), we found that UPEDU and SCRUM agile software processes can be considered with a high compliance, while XP presents a moderate level.

On the general implications on this fulfillment or lack of compliance of these three ASDMs it can suggested the following ones: (i) a nomenclature map among the ISO/IEC 29110 standard and the used in the ASDMs is required; (ii) practitioners can count with UPEDU or SCRUM as the almost already available agile methodologies with a high ISO/IEC 29110 compliance in its PM process; (iii) an enhanced PM process is required for both UPEDU or SCRUM methodologies whether a full compliance level is required; and (ii) specific ISO/IEC 29110 Deployment Packages for UPEDU and SCRUM methodologies are required for fostering its utilization in real VSE settings (for this recommendation the development of Electronic Process Guidelines is also suggested). Hence, this research is an initial roadmap for researchers and developers interested in and requiring a better understanding on the relationships between standards (the ISO/IEC 29110 in particular) and the agile methods.

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