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An Analysis of Specialized Literature about Agile Method Application in the Context of Technical Solution Process Area included in Software Process Quality Models

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Abstract— **This paper aims to present the results of the literature review about the application of agile methods to support the implementation of CMMI and MPS.BR quality models, specifically for the Technical Solution process area and Product Design and Construction process. The research result is to identify which agile methods are applied in the quality models context. In addition, we sought to identify agile practices that support the implementation of these processes.**

Index — *Agile Methods, Software Quality Models, Technical Solution, Product Design and Construction, Literature Review.*

I. INTRODUCTION

The development of information systems or applications is a tool that offers a competitive differential for the consumer market. Hence, the process of creating these tools must be planned and executed with huge dedication and quality.

Software Engineering is a systematic and disciplinied approach for software development [1]. Quality models offer precise goals applied to the context of software engineering with the goal of reaching quality processes of software development.

In the context of good practices embedded in those quality models is the technical solutions process area,

also called product design and construction process, which was chosen for this research.

We chose this are based on the set of evaluations perfomed by MPS.BR (Brazilian Software Improvement Process) that state that only 2 organizations are certified at the process level (D level) and a few companies are certified at levels E, F and G. This may mean that in the next years the organizations that continue following MPS.BR will reach level D and there is the need to offer support for this goal to be reached.

Hence, this paper intends to perform an analysis of the literature on the application of agile methods on the technical solution process area that is contained within software quality models. We also focus on how each practice is used to reach the goals and purposes in the processes included in quality models. Agile methods come as an alternative to software development, being able to provide support for organizations that seek to implement quality models.

This way, the main contribution of this work is the identification of which agile methods, according to the specialized literature, may support the implementation of quality methods. Another contribution is related to the identification of the methods that have practices directly related to software engineering that were not mentioned in the researched papers.

Besides this introduction, this paper is organized in five sections. Section 2 contextualizes our work, presents quality models and the agile methods under study. Section 3 presents the protocol established to perform the informal literature review. Section 4 analyses the results found presenting the main articles that were selected and Section 5 offers a synthesis of the review results. Finally, Section 6 presents final

considerations on the work performed, the main limitations and some future work.

II. CONTEXT OF THIS WORK

In the globalized world we live in, it is unthinkable not to use software, either for the finantial operations from a large bank or to control the stock of a small store. In this scenario of great dependendcy on software, the companies that make them seek for competitive differentials to attract more customers, better manage their budget and their production time, improve the business goals, cese rework and improve the synchrony with project requisites, among other goals [29].

Seeking this differential, the software development organizations have different models that present the goals they seek to build a quality software, such as the CMMI - *Capability Maturity Model Integration* [2] and the MPS.BR [3] models.

In parallel to the quality models, agile methods allow to embrace changes more naturally and to adapt at any momento for the development of a software product [26]. This occurs because the creation context, which is strongly base on the Toyota model (lean production). On the other hand the more traditional models were influenced by the Ford model on which manufacture is based. We intend to show that the implementation of a quality model must be as adaptive as possible to the reality of the organization and of the project. Hence, we can see the need for leaner procedures and softwares that help people get better management of their software processes, achieving the goal of joining the concepts of agile methods and those that are depicted in programs such as MPS.BR and CMMI.

The effective construction of the software product is contained withing the product development process and is related to a process are that the CMMI defined as the technical solution, whose goal is to offer subsidies to design, develop and implement solutions for the requisites [2]. At the MPS.BR the is the process of Product Design and Construction whose goal is to design, develop and implement solutions that comply with the requisites [3].

In order to build a product or solution, some agile methods focus on this activity [9]. Next we will offer a bried description of the agile methods that support the implementation of this area of technical solution process.

Crystal is a family of methods that emphasizes "maneuverability" and whose main goal is to deliver useful working software [4]. The central elements in Crystal are the roles, the process patterns, the work products and the specific practices.

Lean is based on the Toyota product development system and its goal is to make software development "lean", adapactable, focused on the quick solution of problems and the simultaneous quality improvement [5].

TDD - *Test-Driven Development* is a method of software development in which we must first write a unit text (a test at the component level) before writing code [6].

XP - *eXtreme Programming* defines coding as the main activity withing a software project [7]. It is a method for small and medium sized teams that develop software with vague requisites that may change quickly.

FDD - *Feature Driven Development* is a practical process model for object oriented software engineering [8]. Its development characteristic is to focus on the quick delivery (two weeks or less) of the features most values by the customer.

SCRUM is an iterative and incremental development framework for management and agile development of software projects [27]. It is a way to plan and manage projects that brings decision-making authority to levels of operational propriety and certainty.

Finally, Agile RUP follows the main characteristics of the Rational Unified Process (RUP) but synthesizing these characteristics in an agile methodology [28]. As the RUP, this method focuses on the incremental iterative development process in a life cycle that is structured in order to be directed for the collaborative nature of software development.

This way, we can see that there is a great diversity of agile methods and practices that may be used in a development environment and, more specifically for the implementation of the processes within a quality model. The biggest challenge is to define a set of practices that should be used within an organization, from the implantation to the maintenance and evolution.

III. INFORMAL LITERATURE REVIEW PROTOCOL

The informal literature review protocol was define as the following set of activities defined to better structure the review: Defining the goals, the research question, the selection criteria and the data sources; Composig the search string; Defining criteria for article selection and Compiling the data.

The informal review has the following main goals:

- Identifying papers and scientific works related to the issue at hand;
- Allow for the analysis of the utilized methods and approaches;
- Present an extense set of practices used in academia and the industy on the technical process solution or on the product construction.

In order to guide the informal literature review and with the goal of investigating the proposals, the research question was defines as: "*Which methods or agile practices are used to implement the area of technical solution process or product construction?*".

Beisdes this main question, a secondary question was identified: "*Among the agile methods found, which ones contemplate the implementation of quality methods?*".

Another step of this informat review is to choose the criteria for the selection of the data sources. We established the following criteria:

- Availability through the web;
- Availability of articles in English or Portuguese;
- Availability of full text through Internet searches or from the domain of the Federal University of Pará.

The selected sources were: IEEE, ACM, EL COMPEDEX and SCOPUS. Besides the international databases, we used the annals of the Brazilian Workshop on Software Qulity (SBQS) and the Annual Workshop of MPS (WAMPS).

We used two methods to perform the searches: automatics and manual. The manual procedure was applied to the annals of SBQS and WAMPS, given that they do not have a search engine available. The automatic procedure was applied to the international bases through search strings executed at the search engine of each base.

We needed to define a set of keywords and their combination to perform the searches, forming a search string whose goal is to filter the articles in order to find the expected content.

Based on the central questin defined in this section, we identified the following keywords for the contexto f Software Engineering, according to [1]:

- In English: *software, process, PCP, product design and construction, software development e technical solution* (in Portuguese we used their translated counterparts).

In the context of agile methods, we identified the following keywords, according to [26]:

- In English: *agile methods, agile, agility, agile approach e agile practice* (in Portuguese we used their translated counterparts).

In the context of quality models, we identified the following keywords, according to [2] and [3]:

- In English: *MPS, MPS.BR, CMMI, quality models e process improvement* (in Portuguese we used their translated counterparts).

After the identification of the keywords, the search string was formed by *(keywords in the context of software engineering) AND (keywords in the context of agile methods) AND (keywords in the context of quality models)*

After performing the searches, we read the Abstract section to select the articles and refine the search. The selection creiterion for the outlines was: relate quality models with agile methods and have indication of using practices to implement either the area of technical solution processo or the area of product design and construction process.

The last phase of this protocol is to compile the data extracted from the selected articles. This compilation resulted in quantitative e qualitative data that are presented in Section IV.

IV. ANÁLISE DA REVISÃO DE LITERATURA

After the initial selection from the international and national sources, we found the number of articles depicted in Table I.

TABLE I. Number of Articles per Source

Sources	Number of Articles
ACM	6
Ei COMPEDEX	1
IEEE	18
SCOPUS	1
SBQS	10
WAMPS	4
TOTAL	40

Thw work by Marçal *et al.* [10] seeke to present a mapping from SCRUM to the CMMI. For that CMMI process areas that deal with project management were presented: *Project Planning* (PP), *Project Monitoring and Control* (PMC), *Supplier Agreement Management* (SAM), *Integrated Project Management* + IPPD (IPM + IPPD), *Risk Management* (RSKM) and *Quantitative Project Management* (QPM). The mapping was perfomed in order to find gaps, strong points and classification of the SCRUM coverage. The coverage percentual was calculated for each process area, using the classification "Not satisfied", "Partially satisfied" and "Satisfied". After this mapping, the authors performed a gap study between SCRUM and the process areas. In order to validate the mapping, a case study was applied using an online research with organizations interested in improving their project management processes with CMMI and agile methods.

Lukasiewicz and Miller [11] present a mapping from SCRUM to one hundred and twenty three specific CMMI goals. Due to the fact that not all specific goals

were reached by SCRUM, new practices were included keeping the agility. The problem of applying agile methods and quality models is highlighted. In the mapping performed, there are eight CMMI practices, two totals, three partials and three non-existent for coverage of the technical solution process area. The result of the study was the creation of a model (C-S). A questionnaire to diagnose the environment was developed and applied in two organizations. Besides, the authors present an algorithm to select between agile practices.

Sutherland *et al.* [12] intend to present an application of the agile methods SCRUM and Lean in a CMMI Level 5 organizatio. The experience from using Lean and its practice of knowledge spread throughout the organization, its lean mentality and continuous improvement were introduced before SCRUM. Two pilot projects were development: a big one, with more than four thousand hours of work and a small one, with less than four thousand hours. In the large project, SCRUM increased productivity by 201%. In the smaller project, there was not a large change in productivity. Using user stories and incremental testing reduced the project time. One approach that generated implementation success for the agile practices was the adaptation of some already existing project activites for agile practices.

The authors in [10] [11] [12] present the relationship between the areas of interest and agile methods, but only in [11] there is reference to the technical solution process, and the others present agile practices more related to the SCRUM framework.

Ramasubbu and Balan [13] seek to investigate teams that chose to implement CMMI and agile methods. They gathered data from 112 (one hundred and twelve) projects, out of which 34 (thirty four) used agile methods (agile RUP, XP and SCRUM). The process evaluation used five variables: productivity (source code per peron/hour), Bug Density, Reuse, Rework (time spent to correct bugs) and project management effort. Aspects related to the degree of customer involvement, specific knowledge of the client and the familiarity of the team with the technology under use were also analyzed. As a result, it was empirically identified that using agile practices can lead to better results. Besides, they extracted the metric to evaluate the CMMI implementation process together with agile methods.

Anderson [14] presented na expansion of the MFS method, the methodology used internally at Microsoft, with agile practices and adherence to the CMMI. The philosophical conception of the MFS method is presented, as well as the metric analysys and capture method for agile teams. For each process activity the authors define minimum and maximum limits and if the

calculated metric is within this range, the process is controlled. Otherwise, it is out of control. The authors also present agile practice is a scattered way in the article, with more emphasis on the SCRUM practices.

The papers [13][14], even though they mention agile methods, did not present any agile practice related to the technical solution process. Besides, in [14] the authors explore the MFS method as a full solution to reach the CMMI level 5.

Baker [15] combined agile practices to reach the CMMI goals. He presents how to plan the implantation process within an organization. In this organization, specialized teams were created: CMMI committee, evaluation team, area teams (software engineering, project management, requisite management and organizational process). The biggest challenge indicated in the paper was the synchronization of the communication among teams. Retrospective sessions between the teams were performed to decrease the communication problem, a practice that was supported by using the time-box.

Lima and Dan [16], on the other hand, intended to analyze in depth the implementation of agile methods combined with CMMI in small and medium sized organizations. They mapped the practices of SCRUM and CMMI and concluded that they can coexist in the context of project management. For the activities of project management, SCRUM cannot support all the practices of CMMI. Nevertheless, if adapted, this support can be provided. For configuration management and product and process quality assurance, SCRUM does not have any related practices. The authors concluded that there was a need to adopt other agile practices together with SCRUM in order to reach higher maturity levels.

Hansen and Baggesen [17] present a report on the experience of using agile approaches for software development. Initially they performed the implantation of CMMI level 3 and then the agile approaches were used. Investments in training for the institutionalization of SCRUM within the organization were performed. The practice of daily meetings and code reviews helped improve the quality. Besides, the inclusion of a product owner in the same environment of the development team facilitated the communication and promoted mutual trust.

The works [11] [15] [16] [17] indicated the agile practices used but did not detail how each practice was used, as well as the level of support from each practice to the specific CMMI goals. In [17] the authors did not map from the agile practices to CMMI. In [16] this mapping was performed in a higer level, only between CMMI areas. In [15] the focus was on the report on the execution of the process implantation, with no further

details on the application of agile practices and no deeper description of its association with CMMI.

The goal of the work by Fecarotta [18] is to present the lessons learned in the process of implementation of agile methods in an organization. Aspects such as training, project management tool selection, process transparency and consensus are highlighted in the article. In spite of this importance, there was no presentation of how the implementation was performed, as well as no detail on the agile practices involved in the process.

Cohan e Glazer [19] presented the steps to achieve CMMI level 5 with the agile discipline. The organization studied already worked with the implementation of quality models from CMMI level 2 up to CMMI level 5. The base process was SCRUM and the metrics were inserted to achieve those goals. The retrospective practice was used to the continuous improvement of the process. Besides, this paper presents a list with metrics for each agile subprocess.

The work of Neto and Ferraz [20] presents a hybrid agil development model to develop digital TV applications. This model used the methods SCRUM, XP and hybrid (SCRUM/XP). Two experiments were conducted: the first to evaluate the development of the same application by three different teams, each one using one method and the second experiment to investigate two methods: hybrid and XDTv. Th e latter has as main practices the application prototype model and media flow. The basis of XDTv is SCRUM, but given its specificity a new role was created, the Prototyper. The Scrum Master accumulates the role of Tracker, which originally comes from XP. The experiment showed that the XDTv method is promising and answers to the needs of a specific type of application.

Hence, in papers [15] [17] [18] [19] [20] the agile practices were detailed, but the indication of which agile practices answers to each specific goal was not given. In [20] there was no greater details on which practices were used in each process activity.

Navarrete *et al.* [21] proposed a framework for the selection of COTS, na evaluation procedure for the acquisition of a software product based on agile methods and the CMMI. Due to the many changes in the legislation, softwares developed for this niche has as main characteristics the great complexity anf the requirement for maintenance. In the paper there is an association of the process of COTS selection with the agile principles. Project management practices, requisites and quality were related in this work.

The work by Carvalho *et al.* [22] intended to study the integration of agile and traditional processes, defining a hybrid process that gets the advantages of both processes. The resulting hybrid process involved the methods SCRUM and RUP. The research question in this paper was: "Will the hybrid process achieve gains in productivity?". Experiments were performed in medium sized IT companies using function points as metrics. The results showed an increase of 16% in productivity with the hybrid process.

Hasnain [23] presented results of a systematic review on agile methods. The planning, conduction, data extraction, data synthesis and review reprt were duly presented. The key research question was: "what changed in the agile approach as time went by?". In spite of being more used as time elapsed, SCRUM still is not much studied when compared to other agile approaches. Most works deal with success stories on the implementation of agile methods. As a result, it identifies that the papers are presented with a general view, without further explanation and that the practitioners publish papers on experience and students publish empirical studies.

Jakobsen [24] presents the implementation of SCRUM aligned with the CMMI quality model. The practices of SCRUM are more detailed, containing a project management flow, agile practices and tasks concerning specific practices from the CMMI. Aspects such as risk management, quality assurance, tests and configuration management are treated using agile practices. A checklist for the conclusion of user stories may be applied to the process of a technical solution.

Finally, Castro *et al.* [25] present a support tool for organizations to use good practices with the foal of improving the development process. The authors deal with decision support systems, offering good practices for the organizations according to an information input. Attributes such as dynamism, criticality, process culture, domain experience, predictable architecture and personal competence are inputs to the system. Finally a case study was used to validate the tool.

Hence, papers [11] [21] [22] [23] [24] [25] portrait the usage of agile methods to support the implementation of quality models, but there is no indication of any agile practice related to the CMMI technical solution process area.

In [22] the focus is the measurement of the productivity and the practices are only described and grouped by process area. On the other hand, in [23] the study is related to a macro context of agile methods application, with no indication of any practices relating to the technical solution process area. Finally, in [25], in spite of the fact that the article indicates several practices for software development, there are no indicatives of how to achieve practices of the technical solution practice area in the tool.

Another important point is that the great majority of the papers is presented in a general way, with no further explanation or details.

Figure 1 presentes the percentage of papers selected from Brazilian and international sources, showing that 35% of the articles selected came from Brazil and the remaining 65%, from international sources.
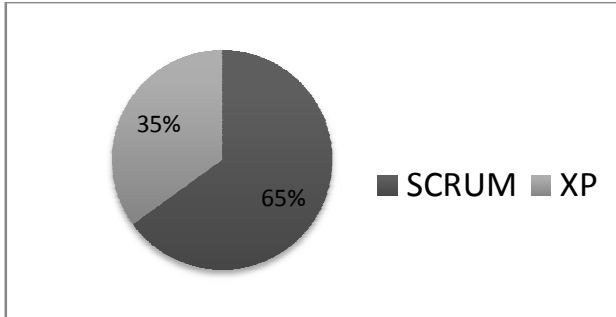

Figure.1. Geographic distribution of the selected articles.

Figure 2 presents the percentage of incidence of methods in the contexto f application of quality models in the Brazilian context, showing 60% citation of SCRUM, 25% for XP and 15% for other approaches (agile modelling, Open UP and RUP).
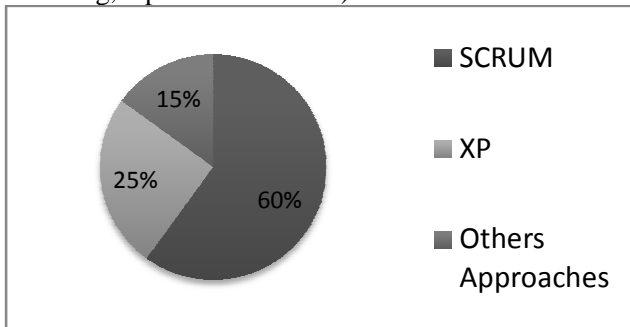

Figure 2. Percentage of citation of the methods in the Brazilian context.

Figure 3 presents the same percentage of citation, but in the international context. There we can see that SCRUM is mentioned 52% of the time, X, 24% and other approaches, 14% (Hybrid SCRUM/XP, Hybrid SCRUM/RUP, agile RUP and RUP).
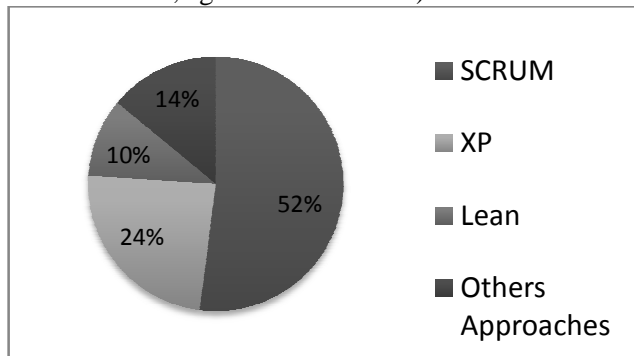

Figure 3. Percentage of citation of the methods in the international context.

The number of citations for SCRUM and XP show that these are the two methods most used to support the implementation of CMMI and MPS.BR quality models.

In spite of the fact that SCRUM does not have practices related to the technical solution process or product design and construction process areas, in SPRINT, for instance, we can insert these agile practices without interfering in the workings of the framework. On the other hand, XP has several practices that support the construction of the solution such as: pair programming, simple design, testing, refactoring, continuous integration, coding patterns and encompassing documentation.

V. SYNTHESIS OF THE RESULTS OF THE LITERATURE REVIEW ANALYSIS

The process of specialized literature review analysis performed sought to answer the research questions detailed in Section III. Nevertheless, in respect to the issue of identifying which agile practices support the technical solution process area or product design and construction process, the result only met the expectations partially.

Another result found in this research was the fac that SCRUM is the most used agile methodology in the Barzilian context to support the implementation of quality models. Nevertheless, its practices do not have the characteristics that make it possible to specifically support the technical solution process or product design and construction process areas.

In spite of the total of 40 (forty) papers indicated in Table I, as a result of our source analysis, eighteen papers showed practices directly connected to the technical solution process area, while the others are associated to information on the agile methods implementation context in general.

Among the articles with the practices directly related to the process area, there was no study that presented in a detailed fashion the information on the implementation in practice, having only indicatives of the used practices.

The Crystal, TDD and FDD methods were not referenced in the context of the application of agile methods and quality models, but it is not conclusive to exclude them from this context, because there are several practices in those models that have a direct relationship with the technical solution process or product design and construction process areas.

Finally, we can come to the conclusion that the great majority of papers published in the specialized literature on agile methods and quality models refer to:

- Presenting the usage of agile methods focusing on management. This may be justified by the fact that most software companies still have their development processes in maturation when comparing with the software engineering practices contained in the quality models;
- There is no complete adequation of the agile mthods to the software engineering practices withing the quality models. Hence, a proposal for a hybrid framework composed by the integration of several practices from agile methods may help in this goal;
- Incorporation of agile processes in the development process already institutionalized and evaluated by quality models. This may be justified by the recent adhesion of the software industry to agile methods and the adoption of quality models. This analysis serves as an important insight for the industrial and academic community leading them to find a less "traumatic" solution when adapting a process already in use;
- Incorporation of process performance evaluation metrics using agile methods. This type of work allows us to discover important indicators and measurement to use in agile methods, as well as to evaluate processes that use agile practices.

Hence, with this review it becomes clear that we need researches and experimentation both in academia and software industry on the integrated use of agile methods and quality models to reach the goals of software engineering processes. This is clear from the fact that from the papers reviewed here on the implementation of quality models, close to 60% dealt with the association of those research topics.

This may help the community to desmistify the thought that agile development seeks to treat the software production process in a differentiated way, since it understands that it comes from a creative process and produces an intangible assert. Given that the quality models are based of the Fordist thining, dealing with the production of software in a way that is similar to manufactured products.

VI. CONCLUSIONS

In relation to the results found in this research, it became clear from all the works that dealt with implemensions of quality programs, that the association of agile methods to quality models is a reality.

This fact may be associated with the scenario from most of the software companies that have the culture of being characterized as small and medium sized companies, where the process needs to be leaner so that productivity indicators may be reached. The analyzed studies present experiences and application cases that support this Idea.

In spite of this evidence, agile methods are usually binded into emerging behaviors, attitudes and practices, but for quality models it is usually more important to generate evidence on the performing of a task or a goal. In this sense, the complexity of the union between these two approaches makes the quality models application process even more complex. This was seen in the result of this research, because of the several agile practices referenced, as detailed in [30].

This work has the following limitations: (i) the number of articles analyzed, because of the criteria applied for article selection, where some of those previously selected were not available for free download; (ii) the search was executed manually is some sources – this procedure, besides being onerous in relation to time consumed, is susceptible to human failure; (iii) due to the results found, the identification of agile practices to support the technical solution process or product design and construction process areas was partially met.

As future work, we intended to present a detail study containing the agile practices that can be used to support the technical solution process or product design and construction process areas. In that study the agile practices will be directly linked to specific practices from CMMI and the expected results from MPS.BR. Another future work refers to the expansion of this research to other processes from CMMI and MPS.BR, such as product integration, verification, validation and others.

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