CERTICS - A Harmonization with CMMI-DEV Practices for Implementation of Technology Management Competence Area

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Abstract—**This paper proposes a harmonization between a product quality model and a software process model used in the industry, CERTICS (a national Brazilian model) and CMMI-DEV (an international model). The focus of this harmonization is on the Competence Area of Technology Management of CERTICS, which addresses the key question of whether "the software is kept autonomous and technologically competitive". The results of the harmonization are examined step by step, as well as including a review of the harmonization, and were assisted by an expert on the CERTICS and CMMI-DEV models. Thus, this paper aims to correlate the structures of the two models to reduce the implementation time and costs, and to stimulate the execution of multi-model implementations in software development.**

Keywords-software engineering; software quality; technology management; CERTICS; CMMI-DEV; harmonization.

I. INTRODUCTION

The growing use of software in companies means that most manual work is now automated, as well as most business routines [1]. This can be regarded as a benefit since the adoption of software products generates a greater demand for goods and services. The increase in demand leads to a proportional increase in customer requirements. Thus, the requirement for greater quality in software products is increasing, since these customers are becoming more selective with regard to the software products they find acceptable [2].

There are several certified models on the market to ensure the quality of the software products, such as the Capability Maturity Model Integration (CMMI) [3], the International Organization of Standardization / International Electrotechnical Commission (ISO / IEC) 15504 [4] and Six Sigma [5]. In Brazil, there are two models that are gaining prominence, which are Brazilian Software Process Improvement (MPS.BR) [6], and the Certification of National Technology Software and Related Services (CERTICS) [7].

Brazil is a country, which has one of the world's largest range of software products, and every day the requirements of customers regarding the quality and complexity of products is increasing. From this standpoint, it can be observed that companies are increasingly seeking maturity in their software processes so that they can reach international standards of quality and productivity, which are essential for survival in the IT market. However, the cost of certification for a company can be up to US$ 400,000, which is not feasible for micro, small and medium-sized firms, and is a characteristic of Brazilian IT Enterprises. Because of this, the Department of Information Technology of the Ministry of Science, Technology and Innovation launched a number of Government and marketing initiatives, which led to a more aggressive stance to export-oriented software. These involved the creation of models to comply with the features required by national companies, and the recent investment policies for the training and expertise of professionals [6][7].

Despite the wide range of certification models, many companies seek to make improvements in their processes and products by using more than one of these models. The reason for this is that the practices included in a single one cannot fully comply with their requirements for improvement. The great difficulty in the implementation of more than one model is that each has a different kind of structure, which causes conflicts and problems about how to understand the models, which will be implemented in the company. These implementation problems that are found in more than one model can only be reduced by achieving a harmonization between them. This task will help to identify the similarities and differences between the models [8]. This harmonization is fully accepted by the regulatory bodies as a means of obtaining quality in the products and services related to software.

The research question of this paper is about how CERTICS (product quality model) and CMMI-DEV (process quality model) can help to bring about an organizational improvement in an integrated way by using the assets (practices, processes and others) that these models possess. Thus, this research is driven by the need for materials that guide the implementation process of the multi-models (CERTICS and CMMI-DEV) in companies, by providing assets to identify their strengths and weaknesses. Furthermore, this research aims to show the relationship between the CERTICS and CMMI-DEV quality models, by harmonizing their features to show the level of adhesion between their structures and support organizations that want to implement them together. The description of the main objective concerns the application of the practices defined in the quality models for the software process and product.

The extent of the business / scientific problem and its

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challenges is revealed by the number of existing models that focus on improving the quality of software development. The harmonization can help to identify the common features of these models, by providing the software company with an instrument to guide the joint implementation of its practices, and thus reduce time and costs. Thus, the means of tackling this problem is to determine how many assets (practices, processes and others), which are needed to support the implementation of different models, can be applied together in the software company.

In this paper, there are discussions related to the details of the harmonization of the CERTICS model of technology management competence area with the CMMI-DEV model. In describing the similarities between the structures of the models, the coverage criteria and evaluation are performed to validate the correctness of the harmonization between the models. Thus, the purpose of this paper is to design an instrument that can guide the joint implementation of the practices contained in the two models (CMMI and CERTICS).

Several questions need to be addressed in this research: these include the way the nature and scope of the investigated problem are related to the software quality and the improvement of the process and product. They also involve an attempt to ensure that, within the scope of the process improvement in practice, the improvement of the software products can be achieved.

According to CTI Renato Archer [7], the model of CERTICS provides benefits to Brazilian software development companies that seek to gain preference in government procurement and market differentiation, and thus create a positive image of the company as an innovator of software development and technological progress in the country. Until April 2016 this model had 29 products certified and registered on the site [7].

CERTICS is composed of four competence areas. The choice of the Technology Management area for this work was based on the fact that it involves establishing action-driven strategies for research and development (R&D). This includes the absorption and / or acquisition of existing software to be embedded in technologies, based on autonomous and technological innovation. This area makes use of the results of R&D in domain ownership software, together with the relevant technologies used in software. This means that the technological innovations and decision-making capacity in the key software technologies must be introduced to ensure that the software remains technologically competitive [7].

Thus, it is expected that the results of this research will: a) reduce the burden of companies with joint implementation models, b) reduce inconsistencies and conflicts between models, and c) reduce costs through this kind of implementation. The difficulty is how to harmonize two models that are defined by different organizations and decide which practices should be integrated. Finally, this research is constrained by being concentrated in one CERTICS competence area and, for this reason, an expert has been invited to evaluate the harmonization.

This paper is structured as follows. Section II examines some related works, which carry out the harmonization of two or more models, and the two models of this research are discussed in detail. Section III outlines the harmonization of the Technology Management Competence Area of CERTICS with regard to CMMI-DEV practices. Finally, Section IV concludes with some final considerations. These include the results obtained and the limitations of this research, followed by some suggestions for possible future work.

II. Related Works and Background

This section provides an overview of the concepts of the CMMI-DEV and CERTICS models and some related works.

A. Related Works

The work of Baldassarre *et al.* [9] proposes a harmonization model that aims to support and guide companies in the integration, management and alignment of software development and quality management practices, or those that are concerned with improving existing ones. This is possible by mapping the ISO 9001 and Capability Maturity Model Integration for Development (CMMI-DEV) model, using the Goal Question Metrics (GQM) for the definition of operational goals. In this work, the statements of ISO 9001 can be reused in the CMMI assessments.

In [10], Pelszius and Ragaisis put forward a scheme for mapping and matching the maturity levels of the CMMI-DEV model and ISO / IEC 15504. The authors investigated which maturity level of a model was ensured by each level of another one. Thus, the mapping was divided into the following stages: (i) the elements of the CMMI-DEV Process Areas were mapped with the ISO / IEC 15504 process indicators, (ii) a summary of each level mapped by the models, i.e. the CMMI practices were mapped in relation to the ISO / IEC 15504 outputs, (iii) calculating the percentage of the ISO / IEC 15504 process attributes, (iv) defining the indicators that express the capability of each process, such as N for Non-Performed, P for Partially Performed, L for Largely Performed and F for Fully Performed, (v) establishing the capabilities of the ISO / IEC 15504 processes, and (vi) determining the organizational maturity of the ISO / IEC 15504, by ensuring a CMMI-DEV maturity level.

In [11], Garcia-Mireles *et al.* show the results of harmonizing the processes and product quality models. A different approach is adopted in this work, where guidance is given by the improvement goals of the software product quality control. Four stages were defined for the mapping between the process models, which are: (i) analysis models, (ii) definition of mapping, (iii) implementation of mapping, and (iv) evaluation of mapping results.

Finally, in Araújo's work [8] there are two mappings: the first is between the MPS Reference Model for Software (MR-MPS-SW) [6] and the Brazilian Test Process Improvement (MPT.Br) [12] models, and the second is made with the MR-MPS-SW and CERTICS models. On the basis of the results of this research, it was found that the first mapping showed a great adherence to the models used,

while the second mapping showed that the MR-MPS-SW is only slightly adherent to the CERTICS model.

The existence of many frameworks and works dealing with the harmonization of practices included in different quality models, led to the joint implementation and evaluation of these models. It also helped the regulatory bodies to accept the existence of practices that are not yet present in the versions of their models. This brings about improvements in the the organizational process without the need for individual interventions by the large number of models.

B. The CERTICS Model

CERTICS is a Brazilian evaluation methodology that seeks to determine whether or not software is the result of technological development and innovation in the national sphere. In this way, it seeks to assess whether the product developed "creates or expands technological skills that are related to the country, or contributes to the creation of business based on knowledge. This leads to an increase in technological autonomy and innovative capacity." [7].

The CERTICS methodology was designed on the basis of the ISO / IEC 15504-2 standard [4] and aims to define a minimum set of requirements related to technological development and innovation in the country [7].

The CERTICS model is composed of four Competence Areas and sixteen Outcomes. The Competence Areas include the details about the concepts of the resulting software that is used for technological innovation and the development of the country. Each Competence Area has a key feature that describes characteristics that must be reached in order to fulfil the requirements of the model. The competence areas are as follows:

- **Technological Development (DES),** key question - "Is the software the result of technological development in Brazil?",
- **Technology Management (TEC),** key question - "Does the software remain technologically autonomous and competitive?",
- **Business Management (GNE),** key question - "Does the software leverage knowledge-based business and is it driven by these business?", and
- **Continuous Improvement (MEC),** key question - "Is the software the result of continuous improvement originating in the management of personnel, processes and knowledge to support and enhance their development and technological innovation?".

The Competence Areas have a set of outcomes, which, when implemented, must satisfy the goals of the model. The model also provides guidance about how to implement each outcome, as well as a list of examples of work products that illustrate what is desirable to fulfill each outcome [7]. In the domain of this work area, the Outcomes of the Technology Management Competence Area are:

- **TEC.1. Use of Results from Technological R&D -** the software development uses results from Technological Research and Development,
- **TEC.2. Appropriation of Relevant Technologies**, the relevant technologies used in software are appropriated by the Organizational Unit,
- **TEC.3. Introduction of Technological Innovations**, - the introduction of technological innovations in software are stimulated and kept at the Organizational Unit, and
- **TEC.4. Decision-Making Capacity -** the Organizational Unit has a decision-making capacity for the key technologies in the software.

C. The CMMI-DEV Model

CMMI is a maturity model for process improvement that is created by Software Engineering Institute (SEI) to integrate knowledge areas in a single model, such as Systems Engineering (SE), Software Engineering (SW), Integrated Products and Process Development (IPPD) and Supplier Sourcing (SS) [3].

Currently the CMMI is in version 1.3 and is composed of three models, which are: CMMI for Development (CMMI-DEV), which is concerned with development processes, CMMI for Acquisition (CMMI-ACQ), whose focus is on acquisition processes, as well as product and / or services sourcing, and CMMI for Services (CMMI-SVC), which deals with service processes such as maintenance and evolution.

The CMMI structure consists of several elements that are grouped into three categories, which are: a) required components (Specific and Generic Goals), b) expected components (Specific and Generic Practices) and c) informative components (Subpractices, Examples of Work Products, and others). These components assist in the interpretation of the model requirements. Thus, the CMMI-DEV is composed of twenty-two process areas, which consist of its purpose and specific goals for each area supplemented by generic goals, since they are related to all the process areas. The specific goals define unique characteristics for each process area, while the generic goals define characteristics that are common to all the process areas. Each specific goal has a set of specific practices, which are activities that must be taken into account to ensure that the goal is satisfied. Similarly, the generic goals have generic practices.

III. THE HARMONIZATION BETWEEN CERTICS AND CMMI-DEV MODELS

The CERTICS and CMMI-DEV models have different structures, each of which has a set of specific requirements, however, despite the particular features of each model, it can be inferred that the models have elements that can influence the fulfillment of some of the requirements that can be found in both models, according to Table I.

The CERTICS model is formed of Competence Areas, which have a set of practices (outcomes) that must be implemented so that it can fulfill the requirements of the model. Similarly, the CMMI-DEV model has an element called Process Area, which is also composed of many practices that must be implemented to fulfill their goals; these practices are called Specific and Generic Practices.

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TABLE I. ELEMENTS THAT CAN INFLUENCE THE FULFILLMENT OF THE CERTICS AND CMMI-DEV REQUIREMENTS.

CERTICS Elements	CMMI-DEV Elements	
Competence Area	Process Area	
Key Questions	Specific Goals (SG)	Generic Goals (GG)
Outcomes	Specific Practices (SP)	Generic Practices (GP)
Guidelines	Subpractices	Generic Practice Elaborations
Evidences from Processes related with Software	Example of Work Products (WP)	

The Key Questions of the CERTICS model are similar in some respects to the Specific Goals and Generic Goals of CMMI-DEV, because these three elements have a set of characteristics that must be identified in a company to ensure that it fulfills the requirements of the model. Thus, the Outcomes of the CERTICS model have goals that can be equated with the Specific Practices and Generic Practices of CMMI-DEV, since these features represent the details of the requirements with regard to what should be performed as a practice to ensure the goals of these models are achieved.

It should be noted that when guiding the implementation process of these models, both have some elements that help to bring about a correct implementation of the requirements of the models. In the CERTICS model there are Guidelines and in CMMI-DEVthere are Subpractices and Generic Practice Elaborations, which offer guidance about how to implement each kind of model item.

Similarly, it was found that the Evidence of the CERTICS model also had goals that can be equated with the Example Work Products of CMMI-DEV, because these elements can act during the implementation of the models as a reference-point for what can be used so that it can provide evidence that the requirements of each model have been fulfilled.

The set of supporting concepts adopted in this paper defines a set of technologies that can be integrated to assist in the software process appraisal and improvement. In this domain, there are tools, techniques, procedures, processes, roles, methodologies, frameworks, languages, standards, patterns, and so on.

A. The Conformance Analysis of the Competence Area of Technology Management

The competence area of Technology Management has four outcomes, which are designed to ensure that the software remains autonomous and technologically competitive [7].

1) TEC.1: Use of Results from Technological R&D

The TEC.1 outcome seeks to analyze the technologies used in the software development to find out whether the results of the research and technological development (R&D) were applied to the development of the software product.

For this reason, when the CMMI-DEV model was analyzed, it was noted that the CMMI-DEV does not cover this outcome because the model does not require the results of the research and development (R&D) results in its implementation. To obtain this outcome, it would be necessary for the CMMI-DEV practices to provide the use of technological resources, such as those of any project that seeks to define the technical solutions based on R&D, partnerships or investment indicators in R&D related to the software product.

2) TEC.2: Appropriation of Relevant Technologies

The TEC.2 outcome seeks to determine whether the relevant technologies in software development that have been used, are appropriate for the organizational unit. In assessing whether this outcome has been achieved, the organizational unit must demonstrate that action taken for the appropriation of technological knowledge is present in the software, (such as the training of its professionals). Thus, this outcome needs a set of CMMI-DEV Process Areas and Practices to achieve its goals.

In the ***Project Planning (PP)***, the SP.2.3 focuses on data management planning, and the SP.2.5 and SP.2.6 ensure that the planning of the professionals involved in the project is based on their professional profiles and skills as well as the involvement of the stakeholders.

In the ***Project Monitoring and Control (PMC)***, the Specific Practice SP.1.1 allows the monitoring of the practices that were planned in PP.SP.2.5 and PP.SP.2.6, while the SP.1.4 allows the monitoring of data management based on the project plan.

In the ***Organizational Training (OT)***, the SP.1.1 seeks to maintain the training on the basis of organizational strategies and needs. The SP.1.2 determines what the training needs are in the business and what the projects are, while the SP.1.3 seeks to establish and maintain the tactical training plans, as well as the quality of this training to meet the needs that are fulfilled by the SP.1.4. Moreover, with the SP.2.1 it can ensure that the training takes place in accordance with the tactical training plan. The records of these training sessions can be kept by the SP.2.2, while the SP.2.3 makes it possible to evaluate the effectiveness of the training in the company.

The ***Generic Practice GP.2.5*** seeks to ensure that the professionals are able to handle the technology used in the company, by providing training that is suited to the needs of the company.

The coverage in TEC.2 was complete, because the CMMI-DEV had met the requirements of this outcome.

3) TEC.3: Introduction of Technological Innovations

The focus of this outcome is on technological innovation, because it seeks to find out whether the organizational unit has taken steps to introduce and encourage the use of technological innovation in software development. To this extent, this outcome needs a CMMI-DEV Process Area and Practice to achieve its goals.

In the ***Organizational Performance Management (OPM)***, with the SP.2.1 it can initiate and categorize the suggested improvements.

The coverage in TEC.3 was not complete because the

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CMMI-DEV does not have practices for conducting the professional activities for members of the project that set up the schemes for technological innovation. Another requirement is the incorporation of innovative ideas that arise from joint ventures with R&D teams, as well as the software made available for technological innovation.

4) TEC.4: Decision-Making Capacity

The TEC.4 outcome seeks to determine whether the organizational unit has decision-making powers with regard to the relevant technologies that are presented in the software product. Hence, to ensure that this outcome is fulfilled, it is necessary for the organizational unit to prove that it has the authority to make changesin the relevant technologies that are present in the software. Thus, this outcome needs a set of Process Areas and Practices of CMMI-DEV to achieve its goals.

In the ***Organizational Performance Management (OPM)***, the Specific Practice SP.2.2 allows the improvements to be analyzed with regard to the possible effects of achieving the quality goals of the organizational process performance. The SP.2.3 is concerned with validating the improvements selected. In the case of the SP.2.4, it can select and prepare the improvements for implementation in the company, on the basis of an evaluation about costs, benefits and other factors.

The coverage of this outcome was partial because the CMMI-DEV has practices that allow the suggested improvements to be analyzed by selecting, implementing and validating these improvements, but the CMMI-DEVprovides no evidence to support the updates of the relevant technologies that can be found in the software and that can allow a decision to be made in the organizational unit.

B. The Evaluation of the Harmonization of Technology Management

The peer review technique was employed to evaluate the harmonization between the requirements of the CERTICS and CMMI-DEV models outlined in the last section, This was overseen by an expert, who has over five years of experience with the implementation of quality models in software development companies, and has recognized certification in CERTICS and CMMI-DEV models. The expert received the document that contains the harmonization of CERTICS and CMMI-DEV models, and carried out the review in accordance with a set of criteria, which were defined on the basis of Araújos's work [8], as shown in Table II.

When reviewing the harmonization of Technology Management (TEC) Competence Area, the expert detected a problem, which was classified as General (G). It was suggested that an analysis should be conducted of all the CMMI-DEV specific and generic practices that have been mapped in the TEC area with the aim of determining whether they are listed and described at the end of the document. If any mapped practice had not been listed, the expert suggested that it should be included in the document, as a means of enabling the goal of these practices to be understood.

TABLE II. CRITERIA DEFINED FOR THE HARMONIZATION EVALUATION.

Criteria	Definition
TH (Technical High)	Indicates that a problem in a harmonization item was found and, if not changed, would impair the system.
TL (Technical Low)	Indicating that a problem in a harmonization item was found and a change would be appropriate.
E (Editorial)	Indicating that a Portuguese language error was found or the text can be improved.
Q (Questioning)	Indicating that there were doubts about the content.
G (General)	Indicates that in general a commentary is needed.

In TEC 2, the expert found a problem that was classified as TL. Since in this outcome a Generic Practice was unnamed, the expert suggested that its name should be included in the harmonization document.

The expert did not find any problem classified as TH, E or Q.

C. How should the Harmonization be used?

The purpose of the harmonization of CERTICS and CMMI-DEV models is to help businesses that wishing to obtain certifications through multi-model implementations or even by making evaluations of the two models. The use of harmonization can optimize costs, time and effort because the models now have their structures harmonized and interrelated.

It was possible to find and highlight the differences and similarities included in the requirements of CERTICS and CMMI-DEV models. In this way, it can be seen that although some requirements of the models are similar or even complementary, it is not always possible for them to fulfil their goals in the same way. According to Association for Promoting Excellence in Brazilian Software (SOFTEX) [6], this may occur because of the different level of requirements found in some of the practices, outcomes and expected results of the models.

The harmonization spreadsheets have become an important support tool in the joint evaluation or implementation of the models, because they provide inputs that allow adaptation / harmonization in the frameworks of the models and in their expected results, practices and outcomes. This can enable the multi-models to be implemented in companies.

As a result, the company saves time from the implementation of joint models, because it will not have to spend time on separately analyzing the frameworks of the models. This means that it has to determine in what way a model can suit another one. This is because all the structures and requirements, which are the same for all the models, have been identified, harmonized and documented in the harmonization spreadsheet of the models.

IV. CONCLUSION AND FUTURE WORK

This research study has examined the harmonization of Technology Management Competence Area included in CERTICS with CMMI-DEV practices. To achieve its goals,

this research sought to identify the similarities and differences between the CERTICS and CMMI-DEV frameworks by investigating their harmonization. To avoid problems of understanding and inconsistencies, an expert in the models evaluated the harmonization by the peer review technique. The results of this review were analyzed and suggested changes should be implemented to eliminate inconsistencies and problems of understanding problems, which were detected by the expert. The document with the complete harmonization generated after the peer review, including all the CERTICS Competence Areas is available in [13].

The usability of the harmonization of the two models can be corroborated by numerous certifications registered in the CERTICS website [7] about products developed by Brazilian software companies that have also made appraisals of their processes that are outlined in the CMMI website [3]. This shows that there is national interest in the two models.

The lessons learned from this research stem from the fact that there is an analytical and comparison domain between the models. Thus, it is recommended that more than one person perform it, so that any conflicts or uncertainties can be discussed and solved by a peer review.

One drawback of this study is that the harmonization has not been evaluated in a software development company; it has only been evaluated by peer review. An evaluation of the harmonization in a company is being completed in Brazil, and its processes are in accordance with the practices of CMMI-DEV Maturity Level 3. As a result, it is possible to determine whether the harmonization contributed positively or negative to a multi-model implementation. Another drawback is the fact that the peer review has only been performed by a single expert, which means that it can only be a limited view of the results obtained from the research. However, this expert is a part of a team that specifies the CERTICS model, and he has extensive experience with the implementation of the CMMI-DEV model, and reduces the bias of the results obtained from the review.

In the future, we intend to continue expanding this research, and apply it to other enterprises, and thus allow the positive and negative aspects of the use of harmonization in a CERTICS multi-model implementation with the CMMI-DEV to be quantified. Another future study concerns the definition of the complete cycle of a harmonization based on the research results of Araújo's work [8] and the SOFTEX guide [14].

So far now that the case study has not been completed, it is possible to perceive that the benefits of joint implementation are as follows: a reduction in costs and time to fulfill the expected results and practices in CERTICS and CMMI-DEV models, creation of unified and standardized evidences to achieve the two models, and the standardization of technical language, which is employed in these models, to define the software development process.

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REFERENCES

[1] A. G. Cordeiro and A. L. P. Freitas, "Prioritization of requirements and evaluation of software quality as perceived buyers", Ciência da Informação, v. 40, n. 2, Brazil, pp. 24-35, 2012.

[2] itSMF UK, "An Introductory Overview of ITIL® 2011", The IT Service Management Forum UK, London, 2011.

[3] SEI, "CMMI for Development (CMMI-DEV)", Version 1.3, Software Engineering Institute, Carnegie Mellon University, USA, 2010, Available in http://www.cmmiinstitute.com. Retrieved: july/2016.

[4] ISO/IEC, "ISO/IEC 15504-2: Information Technology – Process Assessment - Part 2 -Performing an Assessment", Geneve, 2003.

[5] G. Tennant, "Six Sigma - SPC and TQM in Manufacturing and Services", Gower Publishing, Burlington, 2001.

[6] SOFTEX, "Brazilian Software Process Improvement (MPS.BR) - General Guide: 2016", Brazil, 2016.

[7] CTI Renato Archer, "Reference Model for the CERTICS Evaluation – Detailing Document", Centro de Tecnologia da Informação Renato Archer, Brazil, 2013, Available in http://www.certics.cti.gov.br. Retrieved: july/2016.

[8] L. L. Araújo, "Mapping between MPS.SW and MPT.BR and CERTICS", Dissertação de Mestrado, COPPE/UFRJ, Brazil, 2014.

[9] M. T. Baldassarre, D. Caivano, F. J. Pino, M. Piattini, and G. Visaggio, "Harmonization of ISO/IEC 9001:2000 and CMMI-DEV from a theoretical comparison to a real case application", Springer Science+Business Media. v.20 pp. 309-335, 2011.

[10] S. Pelsdziusand S. Ragaisis, "Comparison of Maturity Levels in CMMI-DEV and ISO/IEC 15504", Applications of Mathematics and Computer Engineering, pp. 117-122, 2011.

[11] G. A. García-Mireles, M. Á. Moraga, F. García, and M. Piattini, "Towards the Harmonization of Process and Product Oriented Software Quality Approaches", Springer-Verlag Systems, Software and Services Process Improvement, pp.133-144, 2012.

[12] SOFTEX RECIFE, "MPT.Br Brazilian Test ProcessImprovement – Model Reference Guide", s.l. : SOFTEX RECIFE, 2011.

[13] F. W. da S. Garcia, "An Approach to Software Quality Multi-Models Implementation adopting CERTICS and CMMI-DEV", Dissertação de Mestrado, PPGCC/UFPA, Brazil, 2016.

[14] SOFTEX, "Implementation Guide - Part 11: Implementation and Evaluation of MR-MPS-SW: 2012 Together with CMMI-DEV v1.3", Brazil, 2012.

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