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A Method Framework for Engineering Process Capability Models

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Abstract. This article introduces a Method Framework for Engineering Process Capability Models. This method framework supports the definition of methods or processes to engineer a Process Capability Model. The main goal is that the method framework is a useful proposal for developing methods and processes for engineering Process Capability Models. The method framework defines seven steps and seven customizations rules.

Keywords: Process Capability Model, PRO2PI.

1 Introduction

Software Process Improvement (SPI), based on a maturity level from a Capability Maturity Model (CMM), is well established in the software industry as a successful mean for improving software intensive organizations [1, 2]. In consequence, there are forces around the successful current SPI that urge for its revision and evolution, in order to deal with further opportunities. One of these forces is related with the need to develop more process capability models. Therefore there is an opportunity to understand how process capability models have been developed and consolidate this knowledge to support the development of new models.

The term Process Capability Model is used to mean models of best practices organized with the concepts of process capability and process maturity [5]. In this sense a Capability Maturity Model, as, for example, the CMMI-DEV model, is a Process Capability Model. A ISO/IEC Process Assessment Model, as for example, the ISO/IEC 15504-5 model, is a Process Capability Model as well.

In order to support the development of new models, this article introduces PRO2PI-MFMOD as a "**M**ethod **F**ramework for Engineering Process Capability **Mod**els as an element of the **PRO2PI** Methodology" [4]. PRO2PI stands for "**Pro**cess Capability **Pro**file ***to*** **P**rocess **I**mprovement"). PRO2PI is an exemplar methodology for a proposed evolution of current SPI area, named MDPEK: {(Process

Capability Profile) **M**odel-**D**riven (**P**rocess Capability **E**ngineering) for (Software, System and other **K**nowledge Working) Intensive Organization} [3].

This article is organized as follows. This first section provides an introduction to the article. The second section presents the objectives. The third section presents the research methodology and process. The fourth section describes experiences in developing PCMs. The fifth section introduces the PRO2PI-MFMOD. The sixth section presents how those processes can be considered as examples of PRO2PI-MFMOD. The seventh section presents how PRO2PI-MFMOD is planning to be used for a complex system. The eighth section presents some initial validation. Finally, the ninety section presents some conclusions.

2 Objectives

A main goal and three unfolded objective goals were defined to guide the development of the method framework. The main goal is that the method framework is a useful proposal for developing methods and processes for engineering Process Capability Models. The first unfolded objective goal (Goal 1) is that the method framework could be consider as a generalization of a given set of processes and methods used to successfully develop process capability models. The second unfolded objective goal (Goal G2) is that it is part of the PRO2PI methodology [3, 4, 5] because developing models is part of the scope of this methodology. The third unfolded objective goal (Goal G3) is that it supports the planning for a process to develop a model for best practices in the SPB Complex System [17].

3 Methodology and Process

The methodology is the sequence of ISO/IEC 15504´s Capability Levels (CL) from CL1, thought CL2, CL3 and CL4, towards CL5 [6]. The process used for the development of this version of the method framework started with a view that we have been at capability level 2 for a process area "process capability model development". That view is supported by an analyses of five previous successful experience in model development. For each one of them a process was planned and followed. Each one of them was managed.

After that, a process with the following activities was planned and performed:

a) identification and initial analyses of five previous experience from our research group and of others previous experience from others;
b) a preliminary version for the method framework;
c) a more disciplined revision of the previous experiences identifying and relating the process used with the draft method framework; and
d) analyses and next version of the method framework in such way that all previous experiences could be seen as examples of instantiation of this method framework.

The initial objective was to develop a method. During the construction, we realize that the variety of situations, however, raised significant risks. Therefore we decide to develop a more abstract methodological to support the definition of methods. The term Method Framework was decided. After a research, we found that this term was already used with similar meaning, similar objective and similar reasons in the MFESA [16]. Therefore we confirm the term Method Framework. The major difference from the meaning of method framework is that because PRO2PI-MFMOD is part of the PRO2PI methodology, the contextual elements are already provided.

4 Structured view of previous experiences

This section presents an overview on five previous successful experiences in model development in which we experiment different processes. In addition experiences from others are presented. For each one of these experiences, a brief description, the process used, and examples of techniques used are provided.

Process for a model from a process: In the development of a Process Capability Model for education [7], a *process for a model from a process* was defined and used. This model was composed by a new process area to cover the activities to prepare and teach a technical course. This process area is defined as a new process for the ISO/IEC 15504-5 model. The strategy was to abstract a process area from the current process used by the teacher. This process was composed by seven phases: (1) description of the current process used by the teacher; (2) analyses of the guidelines defined by the organization; (3) description of an improved process, following the ISO/IEC 15504-5 model, to be used by the teacher; (4) definition of a new process area for ISO/IEC 15504-5 such that improved process is an exemplar implementation; (5) assessment of the current process; and (6) revision and consolidation of the new process area. A specific technique predefined for this process is to abstract a process area from a process.

Process for the MARES model: A specialization of the ISO/IEC 15504-5 model for small software companies was developed as part of o project to develop a Method for Process Assessment in Small Software Companies (MARES) [8]. A *process for the MARES Model*, with nine phases, was planned and followed: (1) state of the art of process improvement in SME review and study of ISO/IEC 15504-5 (2) state of the art of methods and models for SPI in SME, (3) requirements definition for the proposed model; (4) development of a draft model; (5) four study cases using the draft model; (6) revised draft model; and (7) two new case study. A specific technique predefined for this process is to use study case to validate a draft model.

Process for a CMMI specialization to CBSE: For a development of a Process Capability Model for Component based Software Engineering (CBSE) a process was defined and used for the construction of this model [9]. The eight phases of this process are as follows: (i) review the state of the art and state of the practice, in this case, for CBSE, (ii) identify a process capability model more appropriate to be specialized for the domain (in this case CBSE), (iii) identify or define a set of additional process areas to cover the major CBSE specific aspects, (iv) represent these new process areas using the format of the base model, (v) identify process areas from the base model that needs customizations for CBSE and perform those customizations (vi) identify other generic process areas from other relevant models that are relevant for the domain and include them in the model, (vii) consider practices from relevant organization that already implement good CBSE, include those practices as additional sources, and revise the model to cover these practices, and (viii) use the model in CBSE organizations, analyse the results and revise the model. A specific technique predefined for this process is to translate process areas from a specific model (in this case the ISO/IEC 15504-5 model) to correspondent process areas for another model (in this case the CMMI-DEV model).

Process for a CMMI specialization to banking domain: In the development of a specialization of the CMMI-DEV Process Capability Model for software development in the banking domain [10], a *process for a CMMI model specialization* was defined and used. This process was composed by seven phases: (1) characterization of the domain, (2) Selection of some process areas, (3) initial description of the domain, (4) exploration of the domain description and specialization of the selected process areas, (5) revision of the domain description and the process areas specialization, (6) validation; and (7) revision and consolidation. This process was used to specialized two CMMI-DEV process areas for software development in the banking domain. A specific technique predefined for this process is to describe a domain using phrase and related them to some practices of a model in order to determine if a practice from a model has higher, same or less relevance for that domain.

Process for the *SPICE for Research* model: In a development of a ISO/IEC 15504-based Process Capability Model for University Research Laboratory (SPICE for Research Model) [11, 12] a *process for the SPICE for Research Model* was defined and used for the construction of this process capability model. The six phases of this process are as follows: (1) state of the art review, (2) best practices survey, (3) process capability model draft design, (4) process capability model draft development, (5) process capability model validation, and (6) process capability model version 1.0. A specific technique predefined for this process is to perform extensive literature review to understand best practices for a domain. University Research Laboratory (URLab) is a unique environment that performs knowledge-intensive activities. The SPICE for Research considers the best practices investigated in some URLabs and the technical and scientific literature on knowledge management, research management, organizational management, and capability models. SPICE for Research uses the architecture and some of the most generic processes of the ISO/IEC 15504-5 as a reference. Nowadays, there is a tendency to spread the use of process capability assessment and improvement frameworks for different domains of the knowledge. Therefore, the SPICE for Research is in line with the tenor on process capability models. Two different communities validated SPICE for Research: the community of managers of research and the community of researchers with experience in process improvement [12].

Generic process for consolidated models: There are a set of process capability models that can be considered as more relevant and consolidated models, including the original SW-CMM model, CMMI models (CMMI-DEV, CMMI-SRV and CMMI-ACQ), ISO/IEC 15504 models (ISO/IEC 15504-5), other ISO/IEC conformant models (OOSPICE, Automotive SPICE, Enterprise SPICE), the e-SCM models, the MPS.BR model and the COMPETISOFT model. For neither one of them, we could found a complete documented process about how each one was developed.

There are only general information about some aspects of the development. From an analyses of these information, we estimate a general process to explain it.

Process for a Leadership model: In a development of a Process Capability Model for Leadership of Integrated Virtual Teams, Tuffley [13] defined and used a process with five phases: (1) literature review; (2) process capability model draft development; (3) Cases study using the draft model (4) Results analyses (5) model consolidation (or cycles of 2,3,4).

Method and process for models from requirements transformation: Barefont at alli proposed a method to transform a set of requirements into a Process Capability Model [14]. In a development of a Process Capability Model for IT Service Management as a transformation from the ISO20000 requirement, they used this methodology. The process was: (1) Identify elementary requirements in a collection of requirements, (2) Organize, and structure the requirements, (3) Identify common purposes upon those requirements and organize them towards domain goals, (4) Identify and factorize outcomes from the common purposes and attach them to the related goals, (5) Group activities together under a practice and attach it to the related outcomes, (6) Allocate each practice to a specific capability level, (7) Phrase outcomes and process purpose, (8) Phrase the Base Practices attached to Outcomes, (9) Determine Work Products among the inputs and outputs of the practices.

Process for a model for SaaS: In the development of a reference guide for assessing service providers in the SaaS (Software as a Service) model, a Process Capability Model was produced [15]. In order to accomplish its objectives, quality requirements that providers should meet were elicited. After having been summarized and analyzed, the requirements were mapped to existing standards and reference models. From this mapping, a reference guide proposal for the evaluation of the software development process practiced by SaaS providers was produced. A process was defined and used for the construction of this draft process capability model. The five phases of this process are as follows: (i) literature review, (ii) gathering of requirements, (iii) complementation and determination of the priority among those requirements, (iv) mapping of those requirements, and (v) construction of the reference guide.

5 PRO2PI-MFMOD Method Framework

The PRO2PI-MFMOD method framework for engineering a Process Capability Models. PRO2PI-MFMOD is part of the PRO2PI Methodology. PRO2PI is a multi-model process improvement methodology driven by process capability profiles. As an exemplar methodology for MDPEK, PRO2PI supports process improvement using elements from multiples reference models and other sources. These elements are selected or defined and are integrated as process capability profile. A process capability profile that drives a process improvement under PRO2PI methodology is also named as a PRO2PI. Figure 1 presents the conceptual elements of the PRO2PI methodology, the relationship among them and the name of each one.

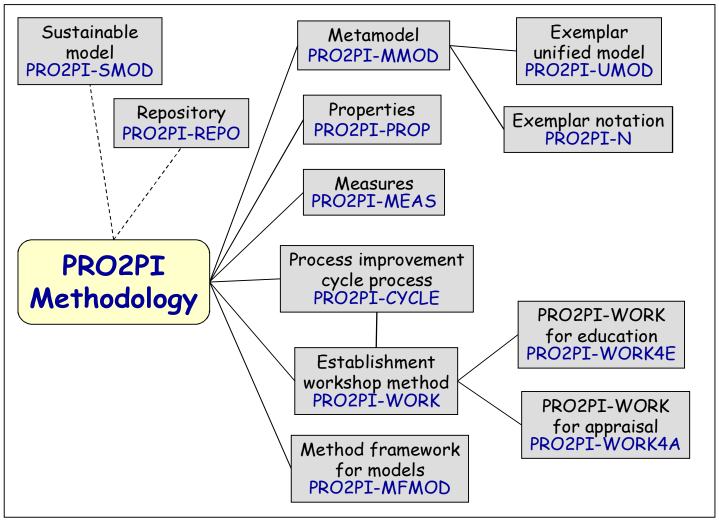


Figure 1 – PRO2PI methodology elements

PRO2PI-SMOD is a **sustainable model** for the dissemination and evolution of PRO2PI methodology. PRO2PI-REPO is a repository for PRO2PI assets. PRO2PI-MMOD is a **metamodel** for a process capability profile and process capability model. Using PRO2PI-MMOD, PRO2PI-UMOD is an exemplar unified process capability model with elements from selected relevant models, and PRO2PI-N is a notation to represent a PRO2PI. PRO2PI-PROP is a set of **properties** for a PRO2PI. PRO2PI-MEAS is a set of **measures** to qualify a PRO2PI. PRO2PI-CYCLE is a **process for process improvement cycles** including a function to define, update or use a PRO2PI.

PRO2PI-WORK is a **method for workshop** to establish a process capability profile to process improvement. This method was developed to guide the implementation of the first three phases and the define and use PRO2PI function of the PRO2PI-CYCLE. In addition, two customized variations of this method was defined. PRO2PI-WORK4A for a workshop with emphasis in the assessment of current practices and PRO2PI-WORK4E for a workshop with emphasis in education of process improvement.

PRO2PI-MFMOD is a **method framework for engineering process capability models** customizes based on context and characteristics of a segment or domain. PRO2PI-MFMOD defines seven sequential steps to guide the development of a method or a process to engine a Process Capability Model (Figure 2).

The first step of PRO2PI-MFMOD is *Initial decisions*. Initial decision related with any one of the following six steps, can be taken in this phase. The second step is *Sources analysis*. In this step we identified, gather and analysed sources for good practices. These sources can include literature, surveys of practitioners, and others. The third step is *Strategy for development*. The decision about the strategy to be used to develop the model. One key issue is how the community of interest will be involved.

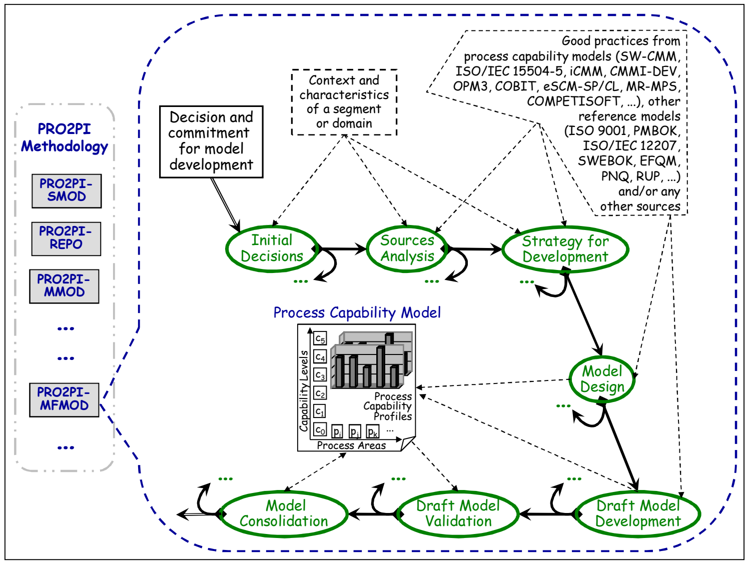


Figure 2- PRO2PI-MFMOD´s seven sequential steps

The fourth step is *Model design*. ISO/IEC 15504 establish as general structure for model design as Process Reference Model and Process Assessment Model. The fifth step is *Draft model development*. The sixth step is *Draft model validation*. The seventh step is *Model consolidation*. From an analyses of the validation of draft model, a consolidation is performed to improve the model.

As part of the method framework, these seven sequential steps, must be customized by a method or even by a process. This customization is oriented by combinations of six simple customization rules (CR1 to CR7). In order to differentiate the method framework from the method or process, we call the elements of the method or process as phase and the elements of the method framework as step. In this ways, the six customization rules are described as follows, in terms of the relationship between the method framework steps and the method or process phase:

CR1: A phase corresponds to a step;

CR2: There is no phase that correspond to a step, because the results to be produced by the step execution are already predefined by the method or process;

CR3: There are no phases that correspond to one or more consecutives final steps, because the life cycle of the method or process ends before those final steps;

CR4: Two or more phases correspond to one step, because the phases are more detailed customization of the step;

CR5: A phase corresponds to two or more consecutive steps, because the phase is a more general and simplified customization of the steps;

CR6: There are consecutive phases that correspond to cycles of consecutive steps; and

CR7: There is one or more technique that is specified for a phase.

The next section provides representations of those processes (described in section 4) as customizations of the method framework and explain these customizations in terms of applications of these customizations rules. In this way, the next section helps the understand of these customizations rules.

6 Processes and PRO2PI-MFMOD

Table 1 shows the PRO2PI-MFMOD´s seven steps and the phases of each one of the five processes descried in section 4 and indicate how each phase is related with the steps. This table and a next one support an analyses of the method framework.

Table 1 – PRO2PI-MFMOD and five processes

Process	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
PRO2PI-MFMOD	1 →	2 →	3 →	4 →	5 →	6 →	7
for a model from a process		1 → 2 → 3 →	4		→	5 → 6	
for the MARES model		1 → 2 →	3 →	4	→	5 →	6 → 7
for a CMMI specialization to CBSE		1 → ; 7	2 →	3 → ; 5 ; 6	4	8	
for a CMMI specialization to banking		1 →		2 → 3 →	4 → 5 →	6 →	7
for the *SPICE for Research*		1 → 2 →		3 →	4 →	5 →	6

The *process for a model from a process* can be consider as a customization of the method framework with the following applications of the customization rules: (a) rule CR2 is applied related with step 1 because the initial decisions were already taken before the process was defined; (b) rule CR4 is applied because the phases 1, 2 and 3 are more detailed than the correspondent step 2; (c) rule CR5 is applied because the phase 4 is more general and simple than the correspondents steps 3, 4 and 5; (d) rule CR4 is applied again because the phases 5 and 6 are more detailed than the correspondent step 6; and (e) rule CR7 is applied because the process finished with the validation of the model draft version, and then there is no phase that correspond to the final step 7.

The *process for the MARES mode* can be consider as a customization of the method framework with the following applications of the customization rules: (a) rule CR2 is applied related with step 1 because the initial decisions were already taken before the process was defined; (b) rule CR4 is applied because the phases 1 and 2 are more detailed than the correspondent step 2; (c) rule CR1 is applied because the phase 3 corresponds to step 3; (d) rule CR5 is applied because the phase 4 is more general and simple than the correspondents steps 4 and 5; (e) rule CR1 is applied because the phase 5 corresponds to step 6; and (f) rule CR4 is applied again because the phases 6 and 7 are more detailed than the correspondent step 7.

The *process for a CMMI specialization to CBSE* can be consider as a customization of the method framework with the following applications of the customization rules: (a) rule CR2 is applied related with step 1 because the initial decisions were already taken before the process was defined; (b) rule CR1 is applied four times because each one of the phases 1, 2, 3 and 4 corresponds to the steps 2, 3, 4 and 5; (c) rule CR5 is applied four times because each one of the phases 5, 6, 7 and 8 is more general and simple than the correspondents consecutives steps (3 and 4), (3 and 4 again), (2, 3, 4 and 5), and (6 and 7); (d) rule CR6 is applied three times because each one of the phases 5, 6, and 7 are cycles: phase 5 repeats steps 3 and 4, phase 6 repeats steps 3 and 4 again and phase 7 repeats steps 1, 2, 3 and 4.

The *process for a CMMI specialization to banking domain* can be consider as a customization of the method framework with the following applications of the customization rules: (a) rule CR2 is applied related with step 1 because the initial decisions were already taken before the process was defined; (b) rule CR1 is applied because the phase 1 corresponds to step 2; (c) rule CR2 is applied for the no correspond phase for step 3 because the strategy for the development (the result of step 3) was already defined before the process; (d) rule CR4 is applied two times because each one of the consecutive phases (2 and 3) and (4 and 5) corresponds to the steps 4 and 5 respectively; and (e) rule CR1 is applied two times because each one of the phases 6 and 7 correspondents to steps 6 and 7 respectively.

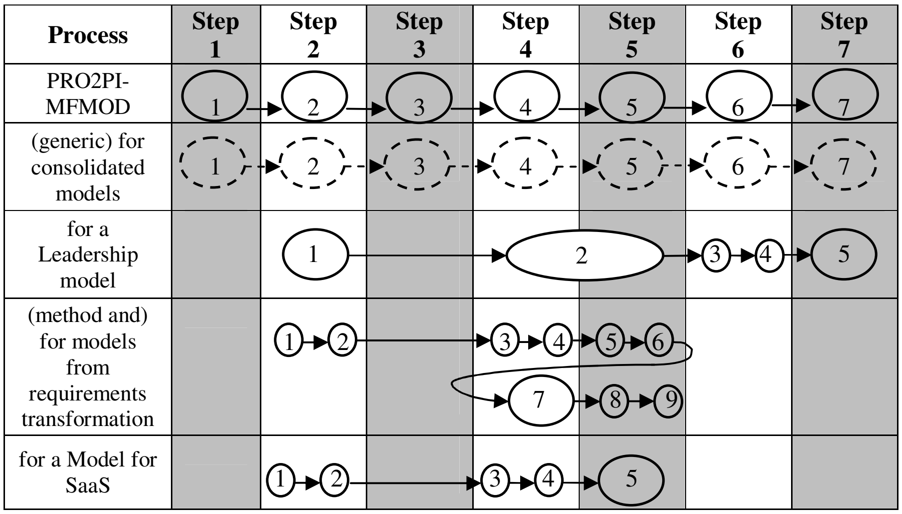
The *process for SPICE for Research* can be consider as a customization of the method framework with the following applications of the customization rules: (a) rule CR2 is applied related with step 1 because the initial decisions were already taken before the process was defined; (b) rule CR4 is applied because the phases 1 and 2 are more detailed than the correspondent step 2; (c) rule CR2 is applied for the no correspond phase for step 3 because the strategy for the development (the result of step 3) was already defined before the process; and (d) rule CR1 is applied four times because each one of the phases 3, 4, 5 and 6 correspondents to steps 4, 5, 6 and 7 respectively.

Table 2 shows the PRO2PI-MFMOD´s seven steps and the phases of each one of the four other processes described in section 4 and indicate how each phase is related with the steps.

8 Using the Method Framework for SPB Complex System

This session will discuss the issues of application of this method framework for building process capability models in the context of complex systems. There is no consensus on the definition of complexity in the literature [18]. In the functionalist sense of the word, complexity refers to a large set of variables whose relations cannot be mapped or monitored [18].

Table 2 – PRO2PI-MFMOD and five other processes



For Demo [19], complexity is linked not only with the number of variables, but with a set of properties for interpreting a phenomenon as complex. The properties highlighted by the author are: the dynamics, the ambiguity, and the no-linearity. What is totally predictable and linear is not complex. These properties above help to characterize the complex a phenomenon as complex. The complex system in focus here is the *Software Publico Brasileiro* (SPB - Brazilian Public Software) [17], which has these three properties listed above.

The concept of software in Brazil has its first public records of discussion in the 90's [17]. The first experiments supported conceptual nuances that had different scales, ranging from the software to be shared only in the public sector to the total release to society. In 1995 the state computing companies, captained by ABEP, began a process of discussion on what later became the concept of SPB [17]. At that time the intention was to accelerate cooperation in the government, in order to reduce developmental efforts, assign costs and rationalize resources. The trend for the total release of solutions to society is recent. Their format comes from the experience of the federal government.

An one year project is under way to consolidate a technical framework for SPB. One part of this project is a subproject to identify and consolidate as process capability models, best practices for developing and evolve a software or a services and best practices to perform a service. This subproject has three sequential phases: (Phase 1) consolidation of this method framework and understanding of the SPB; (Phase 2) development of a draft version of the model; and (Phase 3) validation and consolidation of a initial version of the model. Part of the phase 1 and the complete phase 2 and 3, are already planned as a instantiation of this method framework.

This instantiation is composed of fourteen phases: (i) initial decisions; (ii) sources identifications and initial analyses; (iii) strategy for development; (iv) detailed analyses of the identified sources; (v) detailed of the strategy; (vi) high level model design; (vii) revision of sources and new analyses; (viii) revision of the strategy; (ix) model design; (x) draft model development; (xi) initial validation; (xii) draft model development; (xiii) validation; (xiv) model consolidation. Table 3 shows the phases of this planned process and relate them with the steps of the method framework as applications of the customization rules.

Table 3 – PRO2PI-MFMOD and a process for SPB complex system

Process	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
PRO2PI-MFMOD	1	2	3	4	5	6	7
For SPB complex system	1	2, 4, 7	3, 5, 8	6, 9	10, 11	12, 13	14

8 Initial Validation

Although this is a work in progress, the achievement of the three unfolded objective goals are commented as an initial validation. The achievement of Goal G1 is evidenced by Table 1 and Table 2 showing that the phases of each one of the nine identified processes can be expressed with applications of the seven customizations rules on the seven PRO2PI-MFMOD´s seven steps. The achievement of Goal G2 is evidenced by Figure 1 showing PRO2PI-MFMOD as one element of PRO2PI methodology. Finally the achievement of Goal G3 is evidenced by Table 3 showing that the phases of the planned process for engineering a Process capability Model for SPB complex system can be expressed with applications of the seven customizations rules on the seven PRO2PI-MFMOD´s seven steps.

9 Conclusion

This article introduced PRO2PI-MFMOD as a Method Framework for Engineering Process Capability Models. This method framework supports the definition of methods or processes to engineer a Process Capability Model. The achievement of the the three unfolded objective gave a confidence that PRO2PI-MFMOD is going to fulfil the objective to be a useful proposal for developing methods and processes for engineering Process Capability Models.

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