

# Evaluation and Measure of Maturity Level of Verification and Validation Processes in Cycle of Software Development

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**Abstract** — The management of Validation and Verification (V&V) processes includes activities of monitoring and control during all the software process development (SPD), starting at the beginning of negotiation activities, continuing during the development and finishing after software delivery. Therefore, organizations that need implements these processes, performs a series of actions in order to gain adherence to existing quality models such as TCMM, TMML, CMMI and MPS.Br. There have not been located references of models that allows make of evaluation through checklists and that points to points where there are deficiencies in the processes. In this context, this paper presents a methodology to measure maturity level using the framework GAIA VERO as base tool.

**Keywords**— *Software; Framework; Checklist; Verification; Validation; Quality; Gaia; Vero; Maturity; Capability*

## I. INTRODUCTION

Quality is a mandatory item in a software product. The consumers requires a product with lower rate of fails and errors, that meets their functional and non-functional requirement, that is in according to laws and rules, and that has a competitive cost compared to the benefits.

A study leaded by Standish Group, Chaos Manifesto [5], indicates an improvement in the success rate of project completion between 2010 and 2011, but only 37% of these was finished at deadline, with planned costs and requisites. Of the remaining projects, 42% had delays, increment of costs or specification problems and another 24% were canceled.

Having many aspects and costs involved, the software quality assurance becomes a very important and very complex process of development and maintenance life cycle becomes a very important and very complex process of development and maintenance life cycle. Despite this importance, quality assurance is a commonly overlooked and a relatively low number of support tools and techniques well established and structured.

In quality assurance, highlight the V&V processes, that have great responsibly in the final product quality. For this reason, these processes must have a different treatment with the use of techniques and tools that provide support to the team

in order to promote equilibrium between the costs generated by the process of quality assurance and its inherent costs.

This work presents a tool for measuring maturity levels of V&V processes and that is part of the Gaia Vero that allows the team have a macro view of the quality assurance process, besides the micro view provided by the individual analysis of the processes by measuring their capability.

This paper is organized into the following sections: Section II provides an introduction to models that address V&V and are widely used, in Section III are identified and displayed common problems that cause project failures and compared with existing models, Section IV presents an overview of Vero Gaia framework and its capacity levels, Section V presents the Maturity Levels of Gaia Vero, Section VI presents a study case of the calculation of capability and maturity levels in deployment of Gaia Vero in an organization, and, finally, in Section VII presents the conclusions.

## II. V&V MANAGEMENT

From the moment that started the development of the first computer system, there are frequent cases where the use of V&V processes was and is necessary. Initially, the process was totally experimental, but over time has incorporated principles of quality of other more general areas such as Total Quality Management (TQM), which was already successfully applied in various branches of industry. Based on these concepts was developed Software Quality Control (SWQC).

In 1994 was created the ISO 9001 [2], which is a generic model for implementation of quality systems. Due to difficulties in implementation because of the generality of this model, specific models were created, such as the ISO / IEC 9126 and 14598. Parallel, we developed the CMMI model [1] which provides a reference model that includes practices and activities required to obtain maturity in the SPD.

Many models and frameworks have been created in an attempt to make the management of V&V. Noteworthy are the that are based on maturity and / or capability of processes such as the Testing Maturity Model (TMM), Test Maturity Model integrated (TMMi) and Technical Capability Maturity Model (TCMM).

Currently, has highlight models based on the service oriented paradigm. This type of model provides a better load distribution process requirement while also providing support tools in a flexible way. In this category there are models like Braungarten et al [7] and Gaia Vero [9].

### III. IDENTIFIED PROBLEMS

Many problems and difficulties are part of routine of a quality assurance team. Some of the main problems that affect the final quality of the products are related to failures in the definition and management of requirements, project methodologies, lack of standards development, and failures in registration / use of learned lessons and in the calculating of estimated cost / time and others.

With respect to existing methodologies, the highlights are problems related to the generalization of practices and activities, which causes great difficulties in the implementation process due to the fact that there are practices like "Prepare for Validation" and "Validate Product or Component" present in CMMI and that is a little more detailed in the specific activities.

With very wide practices, it becomes difficult for the team tread a path for the deployment of processes. Thus, Gaia Vero has several services with well-defined focus in order to attack smaller parts of the V & V processes, making it easier to implement and institutionalize them.

In addition to smaller and better defined processes and based on services that provide an overview of specific points where failures may be occurring and that can be analyzed based on their capability, Gaia Vero has a maturity assessment for the management of V&V as a whole that is the focus of this work.

Get an overview of the level of local implementation processes is very useful, but the overall vision allows us to evaluate how much we still have to improve. Understand the critical success factors in a process improvement initiative is essential to support the implementation of best practices [4].

### IV. GAIA VERO FRAMEWORK

A big problem in relation to quality management is how to get a way to measure, ie, how to identify criteria and measure them in order to denote the current level of quality.

Considering the need for a tool that would allow the deployment, management, and measurement of quality of a SPD, was planned, specified and developed a framework Gaia Vero with a view to provide a basis for implementation gradual and flexible of the V&V processes, as well as its management, measurement and benchmarking.

Gaia Vero follows the division of objects proposed in [6] and comprises:

- Tools and Techniques;
- Vocabulary;
- Templates and Documents;
- Workflows;

- Performance Indicators.

Graphically the structure of Gaia Vero objects can be referenced as in Figure 1.



FIGURE 1 - GAIA VERO STRUCTURAL ORGANIZATION

In the group Tools and Techniques, are defined 16 services, and each service is focused on a key concept that commonly causes problems in the V&V processes and thus affect the final quality of the SPD.

These services are arranged into 4 functional groups which are:

- Planning and Standardization (PS) - 7 services;
- Development (DE) - 3 services;
- Finishing and Support (FS) - 3 services;
- Monitoring and Evaluation (ME) - 3 services.

As cited in [9], gaia Vero has 4 levels of capacity for each service to represent an increase in the number and complexity of the activities to deploy.

The capability levels are:

- Capability 0 - not controlled;
- Capability 1 – managed;
- Capability 2 – institutionalized;
- Capability 3 – optimized.

O Gaia Vero framework has checklists that contains the practices and activities to each service available. Each practice can be marked as fully satisfied (S), not satisfied (N), partially implemented (P) and not applicable (NA).

To calculate a capability level must use the formula (1), where %I representes the implementation rate between 0% and 100%, T representes total number of activities of that service except the activities markes as NA. Must be considered the practices required to lower levels.

$$\%I = 100 * \left( \frac{\sum S + \frac{\sum P}{2}}{T} \right) \quad (1)$$

With rate calculated with (1), can determine the capability level based on the classification used by MPS.br [8] and is shown in Table 1.

TABLE 1- RULES FOR DETERMINE CAPABILITY LEVEL OF SERVICES

Implementation Level	Implementation rate
Fully Implemented	%I > 85%
Widely Implemented	50% < %I <= 85%
Partially Implemented	30% < %I <= 50%
Not Implemented	%I <= 30%

## V. MATURITY LEVELS OF GAIA VERO

Besides the evaluation capability levels, Gaia Vero has an evaluation model based on maturity levels. The level of maturity measures the degree of adherence of the organization's processes through the implementation of services.

For each maturity level was defined a set of services that must be implemented so that it can consider that the organization has adherence to this level. To be considered implemented, a service should be considered "Fully Implemented" in relation to its maximum capacity.

During the evaluation of the maturity level, must consider that all services of the previous level must be implemented and evaluated capability level 3, and is accepted that up to 1 service of desired level has capability level as level 2 "Widely Implemented" and, necessarily, all others must have the capability "Fully Implemented".

Table 2 shown a list with maturity levels and the services that compose them.

TABLE 2 - DISTRIBUTION OF SERVICES IN MATURITIES LEVELS

Level	Services
<b>0 - Not Controlled</b>	None service is officially executed
<b>1 - Partially Managed</b>	PS01 – Requirement Revision PS02 – Modeling Revision PS04 – Methodology Definition Revision PS06 – Revision of Politics, Procedures and Standard FS03 - Revision of Helpdesk Training
<b>2 - Managed</b>	PS07 – Revision of Definitions and Use of Acceptance Criteria DE01 – Revision of Code Inspect ME01 – Review and Execution of Tests
<b>3 - Quantitatively Managed</b>	DE02 – Support Tools Revision DE03 – Revision of Definition of Purchase Criteria FS01 – Learned Lessons Revision ME03 – Revision of Base of Time/Cost Calculus
<b>4 – Optimized</b>	PS03 – Test Plan Revision PS05 – Training Revision FS02 – Revision of Systems and Procedures Manuals ME02 – Revision of Quality Indicators

Graphically we can represent the maturity levels of Gaia Vero as shown in Figure 2, where it is also presented the main results expected for each level.



FIGURE 2 – MATURITY LEVELS - GAIA VERO

As shown, there are five maturity levels, which are defined according to the number, degree of difficulty and degree of implementation of the services available and will be detailed below.

### a) Level 0 – Not Controlled

The process has the characteristic of being highly unpredictable, and at times of extreme stress can be chaotic. Few processes are performed or are performed in a mode not defined and standardized. In general, the result of process executed is highly dependent on team members.

### b) Level 1 – Partially Managed

In level partially managed, is one of the hardest steps, due to the fact of the total lack of previous organization, but at this level the processes begin to be organized, allowing control over fundamental aspects in any software development, focusing on the pre-development and covering services that work with the requirements, the modeling methodology, the technique to manage the project, the structuring of company policies in relation to several factors and the definition of user support staff training.

### c) Level 2 – Managed

In the managed level, it is expected that the organization has already established strong pillars in relation to various aspects of the pre-project and is already able to ascend up new horizons.

At this level are worked acceptance criteria for inclusion of products, libraries, codes and other components developed by others or even by other staff of the organization. These services are very important due to the fact that low quality parts included with the product will result in low quality of the final code developed.

Still at agreement with this premise, we have two more services linked to this level. They are linked to the revision and testing of the developed codes, in order to obtain a code of good quality end of the project.

The practices of this level in combination with the previous level allow management of the most important aspects for an organization of medium level aspects.

d) *Level 3 – Quantitatively Managed*

The maturity level of managed quantitatively addresses the improvement and optimization some aspects of basic management. Are treated aspects related with tools in order to start the optimization process by allowing calculation of quantitative data and lessons learned, as well as support tools, review of acquisition criteria and revision of base table used to calculate cost and time through the register and metrics obtained.

e) *Level 4 – Optimized*

The level of maturity optimized is achieved through continuous process improvement through a revision not only quantitative, but qualitative. In this qualitative review, should be analyzed what is productive or counterproductive in the process, in addition to allowing the inclusion of new practices that can improve control, speed and accuracy of obtaining the metrics and indicators established.

VI. STUDY CASE – CAPABILITY AND MATURITY LEVELS CALCULUS

During the period of implementation of the framework Gaia Vero in a brazilian public organization, one study related to the calculation of their levels of ability and maturity was conducted.

Evaluation checklists were filled for the 16 services components of the framework. Then were calculated capacity rates and in sequence their maturity level and their generated graphics.

Regarding capacity, Figure 3 shows the graph of capacity levels of the 16 services for level 1.

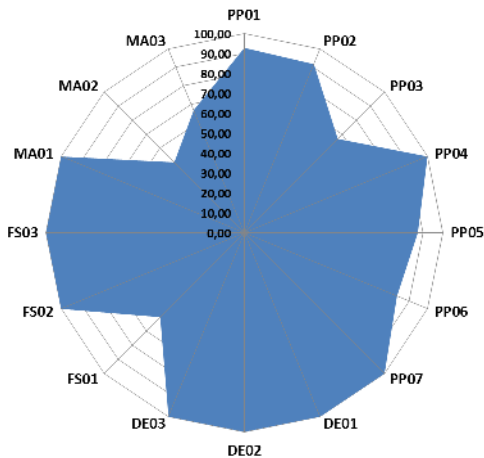


FIGURE 3 – CAPABILITY LEVELS FOR LEVEL 1

Figure 4 shows the graph of capacity levels of the 16 services for level 2.

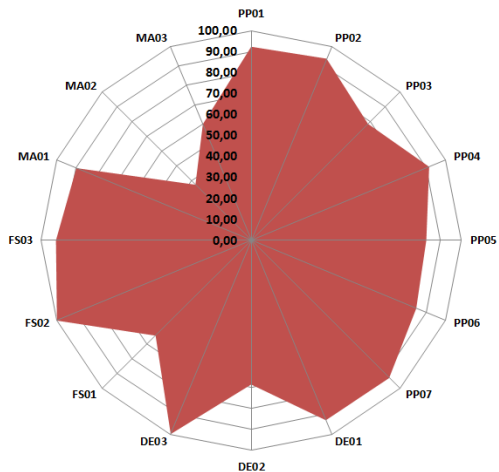


FIGURE 4 – CAPABILITY LEVELS FOR LEVEL 2

Figure 5 shows the graph of capacity levels of the 16 services for level 1.

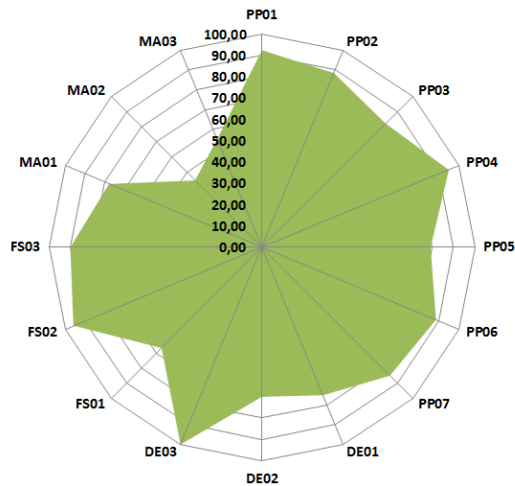


FIGURA 5 – CAPABILITY LEVELS FOR LEVEL 3

The Figura 6 presents a comparative summary of the capacity levels for each level (1,2,3) in each of the 16 services provided by the framework.

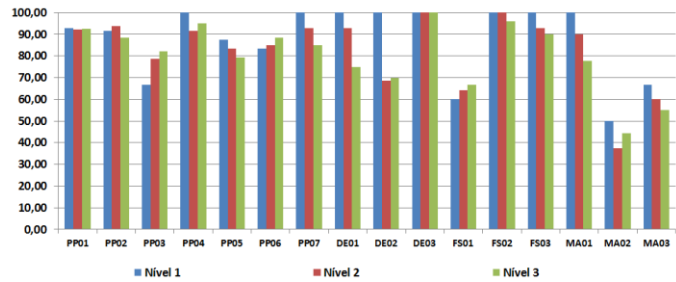


FIGURA 6 – CAPABILITY COMPARATIVE SUMMARY TO SERVICES

Table 3 summarizes the capacity rates obtained along with their level of capability. Given this table, it was possible to mount the table level of process maturity of V&V within this organization.

TABLE 3 – CAPABILITY RATIO RATE

	Level 1	Level 2	Level 3	Level Capab.	Capability Level Description
PS01	92,86	92,31	92,50	3	FULLY IMPLEMENTED
PS02	91,67	93,75	88,46	3	FULLY IMPLEMENTED
PS03	66,67	78,57	82,14	2	WIDELY IMPLEMENTED
PS04	100,00	91,67	95,00	3	FULLY IMPLEMENTED
PS05	87,50	83,33	79,17	2	WIDELY IMPLEMENTED
PS06	83,33	85,00	88,46	3	FULLY IMPLEMENTED
PS07	100,00	92,86	85,00	2	WIDELY IMPLEMENTED
DE01	100,00	92,86	75,00	2	WIDELY IMPLEMENTED
DE02	100,00	68,75	70,00	2	WIDELY IMPLEMENTED
DE03	100,00	100,00	100,00	3	FULLY IMPLEMENTED
FS01	60,00	64,29	66,67	2	WIDELY IMPLEMENTED
FS02	100,00	100,00	95,83	3	FULLY IMPLEMENTED
FS03	100,00	92,86	90,00	3	FULLY IMPLEMENTED
ME01	100,00	90,00	77,78	2	WIDELY IMPLEMENTED
ME02	50,00	37,50	44,44	1	PARTIALLY IMPLEMENTED
ME03	66,67	60,00	55,00	2	WIDELY IMPLEMENTED

TABLE 4 summarizes the maturity level of the V&V processes of the organization, according to Gaia Vero.

TABLE 4 – SUMMARY OF MATURITY LEVEL

Level	Description	Status
0	Not Controlled	OK
1	Partially Managed	OK
2	Managed	NOT OK
3	Quantitatively Managed	NOT OK
4	Optimized	NOT OK

## VII. CONCLUSION

A qualidade como uma característica fundamental do produto é indiscutível. Todos os projetos indistintamente devem perseguir metas de melhoria da qualidade nas suas atividades, uma vez que a qualidade de um software deixou de ser um diferencial competitivo e passou a ser essencial para os consumidores.

Sendo assim, é necessário que o produto apresente baixa incidência de falhas e erros, excelente cobertura das necessidades dos consumidores e bom custo/benefício.

Com base nessas premissas, é imprescindível que todo o PDS passe por auditorias de verificação e validação para cada prática e atividade durante todo o período de desenvolvimento do projeto.

Muitos são os pontos a serem acompanhados e poucas as ferramentas que efetivamente auxiliem e guiem na avaliação dos aspectos envolvidos na garantia da qualidade de um PDS.

Nesta vereda, foi criado o Gaia Vero, que é um framework multi-nível que visa auxiliar no processo de garantia da qualidade, oferecendo processos de monitoramento e acompanhamento dos processos e guiando as atividades a serem desenvolvidas afim de estabelecer um PDS controlado e gerenciado do ponto de vista de nível de qualidade.

O Gaia Vero foca nas atividades de grande impacto em termos de custo, tempo e qualidade do produto, auxiliando na redução de custos finais de desenvolvimento e melhorando as margens de lucro e a competitividade da empresa.

Apresenta, ainda, ferramentas de avaliação de nível de capacidade e de maturidade dos processos da organização, permitindo a análise comparativa de desempenho e a identificação de pontos onde as melhorias podem ser realizadas.

Desta forma, o Gaia Vero apresenta uma proposta que fornece subsídios à gerência para avaliar como está o nível de qualidade do PDS e também propõe que esta avaliação seja constante para que a empresa avaliada possa atingir todos os níveis de maturidade necessários e desejáveis por todos.

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