2DAM-WAVE – An Evaluation Method for the WAVE Capability Model

Rafael A. Glanzner, Jorge Luís Nicolás Audy

Faculdade de Informática (FACIN)
Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS)
Porto Alegre – RS – Brasil
rafael.glanzner@acad.pucrs.br, audy@pucrs.br

Abstract— **The purpose of this paper is to present the 2DAM-WAVE, an evaluation method that enables organizations to assess their capability in global software development and to discover improvement opportunities. Organizations can be evaluated in two ways, using questionnaires on a web tool, that gives a fast but undetailed result and a more resourceful way, that uses interviews and artifacts analysis for more detailed and extensive results. This evaluation method uses as reference the WAVE capability model, which documents patterns of evolution in the practice of the internal offshoring of software. This evaluation method has been used in a Brazilian unit of a large company and is already scheduled to be applied to an Indian unit of another big company.**

Global Software Development; WAVE; Capability Model; Evaluation Method

I. INTRODUCTION

The increasing globalization of recent decades has caused an impact on many industry sectors, and this phenomenon was not different in software development [1, 2]. Based on these transformations, the Global Software Development (GSD) has aroused, which is characterized as a software project developed by dispersed teams in global scale [3]. This approach has attracted much attention from the academy and organizations, as if used with maturity, the concepts of GSD can assist companies in reducing costs, time-to-market and in the increasing of its global presence, among others advantages [4].

The interest in its development and use, becomes evident when it is found that 300 of the 900 member companies of NASSCOM (National Association of Software Companies), located in India, work with DDS in the Offshore Insourcing model [5]. This model is characterized by globally distributed software development within a single organization, while the Offshore Outsourcing model is outsourcing a part of the project to another existing organization in another country [6].

Regarding the distributed software development in the Offshore insourcing modality [7], there was not yet any capability model that had the aim of helping companies to continuously improve its technical and nontechnical business processes. The WAVE capability model [8] was designed to fill this gap by suggesting improvements in the areas of people, projects, unit and portfolio. However, even before this research, the WAVE did not have a evaluation method.

Building an evaluation method for the WAVE model is important for its effective use by the industry and also the academy. With this proposed method, it is possible to evaluate the capability level of companies, proposing improvements based on evaluation results. Furthermore, organizations can, with these evaluation results, outline improvement plans for their units and make strategic decisions grounded in WAVE evaluations.

The importance of evaluation methods for quality models is perceived as we verify that the two main models of international improvement, CMMI and ISO 15504 [9] and many others, have methods of evaluation. Examples of quality models and their evaluation methods are CMMI [10] and SCAMPI [11], ISO 15504 [12] and SPICE, MPS.BR [13] and MA-MPS [14], among others. Without these evaluation methods would be impossible to identify at what level of maturity a particular company would be at CMMI, MPS-BR or many other models.

This research proposes a method of evaluation for the WAVE, called 2DAM-WAVE enabling organizations wishing to implement the best WAVE practices, find out in which capability stage they are.

II. CAPABILITY AND MATURITY MODELS

A capability or maturity model usually aims to show how capable or mature an organization is in a particular area or activity as well as helping improve its processes through a collection of best practices. There are several capability and / or maturity models to various areas of study and these are not unique to software engineering area. CMM [15], CMMI [10], ISO 15504 [16] and MPS.BR [13] are examples.

These models are adopted by many organizations, because they are based on academic studies and in the best practices performed in the industry, becoming excellent guides for organizations seeking to improve their processes. Furthermore, organizations with considered high levels of maturity and / or capability in models that are prestigious in the industry, use these achievements to get clients that require suppliers with high levels of quality.

There are significant differences between capability, maturity and models that add the two settings. Maturity models are organized by stages, considering that a company evolves of stage implementing various improvements which together increase its maturity.

The capability models are different, because there is no concept of stage, but of continuity. In capability models, a company can choose one or more areas of the model to improve. Thus, companies can get maximum level in some areas and minimum level in others.

Capability or maturity models are more easily implemented if they have at least one evaluation method. An assessment method is defined as a set of activities which must be executed to conduct properly the evaluation [17]. The evaluation methods usually take into account the objectives and constraints of the company. Without this information, its validity is doubted, because it will not generate the expected benefits for the organization.

Evaluations are applied to companies in different contexts and with different goals. Evaluations can be performed with a company's internal staff in order to measure the evolution of its processes and the actual effectiveness of implemented improvements. In other cases, evaluations are conducted with external teams, in order to certify a company at a certain level of maturity or capability. Evaluations can have different scopes, settings and objectives.

Whatever the case is, it is important that the evaluation reflects the state of an organization and that the improvements suggested are really relevant to the objectives of the organization. Therefore, it is important that the evaluation is focused on processes that must be effectively improved and that, if the list of improvements is too large, they are placed on scales of priorities.

There are several methods of evaluation proposed and used in different maturity and / or capability models, each of them with distinct characteristics, advantages and disadvantages. SCAMPI [11], MA-MPS [14], CBA IPI [18], are examples of evaluation methods.

III. WAVE – Capability Model

The WAVE capability model [8] aims to help the organizations units to increase their capability to develop projects with globally distributed teams. The WAVE model was the first capability model created with a focus on companies that operate in the context of offshore insourcing, but the WAVE can also be used by companies working with offshore outsourcing [8].

The WAVE is structured in "Capability Levels", "Capability Areas", "Capability Attributes", "Objectives" and "Practices." The model is divided into four major capability areas, which are: "People", "Projects", "Portfolio" and "Unit." Each of these capability areas group common nature attributes. The capability attributes, in turn, are points to be monitored when working in the context of GSD. The WAVE capability areas and attributes are shown in Table 1.

TABLE 1   WAVE CAPABILITY AREAS AND ATTRIBUTES

Capability Area	Attribute
People	Cultural Differences
People	Confidence gaining
People	Awareness of activities
People	Awareness of the process
People	Awareness of staff availability
People	Knowledge Management
People	Levels of dispersion
People	Learning
People	GSD Training
People	Perceived distance between the distributed units
Projects	Engineering of requirements
Projects	Communication tools
Projects	Collaboration Tools
Projects	Infrastructure
Projects	Project management structure
Projects	Life cycle of software development
Projects	Risk management
Projects	Projects estimated effort
Projects	Configuration management
Projects	Allocation of activities in projects
Projects Portfolio	Types of projects
Projects Portfolio	Projects Allocation
Projects Portfolio	Project Management office (PMO)
Unit	Initiatives to improve software process
Unit	Policies and standards

Each of these capability attributes have a goal, which describes the benefits that this capability attribute brings to the company, if it is well implemented. Also, capability attributes have a number of practices, and as such practices are being implemented, there is obtained a greater capability in this attribute. Figure 1 illustrates the structure of the WAVE capability model.

FIGURE 1 – THE STRUCTURE FROM THE WAVE MODEL
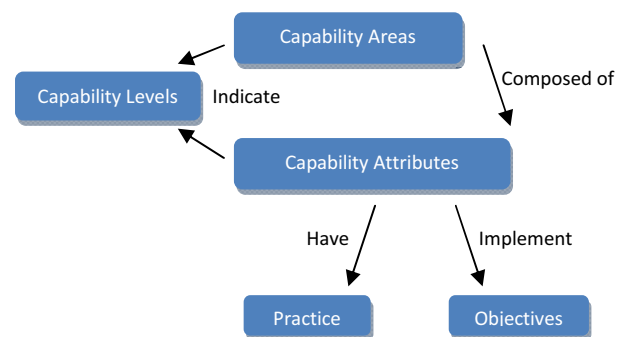
In the WAVE model we can define the level of capability of a unit on three scales which are based on attributes, capability area or general. Whenever a company implements practices from an attribute, it increases its capability on this attribute. Depending on the capability attribute and the desired capability level, more or less practices must be implemented.

When conquering, for example, level two of capability in all attributes of the capability area of people it is obtained level two of capability in this area. In the same way that when conquering level two in all areas of capability, the unit gets capability level two in the WAVE model. It is noteworthy that a unit cannot obtain a level X if it has not implemented all the practices of the immediately preceding level (X - 1).

The WAVE model has a range of four capability levels: ad-hoc (level one), training (level two), preparation (level three) and integration (level four). These levels were based on the eSCM model [19].

At the first level, ad-hoc, are those units that are at the entry level in the use of GSD, implementing a few practices and normally without any basis or improvement plan.

Units on the second level, are those that have implemented basic practices that facilitate the execution of projects in the GSD context. The improvement initiatives are often oriented to some projects and rarely for the entire unit. These efforts are still made on demand and are hardly planned in advance by the organization. The capability attributes most required at this level are the from the capability area of "People", because it is crucial that the evolved teams are trained for this change of paradigm.

When an organization and the units get more experience in globally distributed projects, the initiatives from level two of the WAVE capability model are expanded. Improvements before applied in a single project, when reach the level of preparation, become implemented in a group of projects, in the unit or even in all units. In this level the distributed teams of a project are poorly integrated and are often managed individually.

Finally, the units at the capability level of integration may already have dependences between projects, working in more complex scenarios. In addition, organizational standards on how to work in a GSD context are created.

IV. 2DAM-WAVE

The evaluation method 2DAM-WAVE has two dimensions, a mini evaluation and another most extensive. The most extensive one is based on SCAMPI A, SPICE and MA-MPS while the mini evaluation SCAMPI C uses the MMGP method as a guide. The objective of the most extensive dimension is carefully evaluating the processes and artifacts of the organization. It uses as a source of data, interviews with various employees and the analyzes of the unit documentation, reaching nontrivial conclusions and identifying strengths, weaknesses and improvements to be prioritized. An evaluation like this demands a lot considering time and resources, therefore another dimension must be created for quick assessments.

The mini evaluation must demand less resources and time and is not intended to evaluate the organization with depth, but to make an initial analysis of the quality of its processes. This dimension does not require WAVE experts, and is held in its entirety through of a support tool, collecting evidence through web questionnaires, such as PRADO model [20].

The results of both dimensions from 2DAM-WAVE should be stored in a historical repository for benchmarking. The results of the capabilities of the units assessed, along with the unit information, will make possible to verify, for example, the evolution of the capabilities from the Brazilian units in GSD over the years. Furthermore, it will be possible for the evaluator to verify how the other units solved typical GSD problems in other evaluations, and may use this information to propose improvements in another evaluation. This support tool, with a few changes, can help the evaluated units to compare with other companies in the market. Furthermore, this historical database can provide to the academic community an opportunity to analyze the market trends in this area. This practice is already partially used in MMGP. All the data collected from the companies remain confidential, so it is not possible to see how did a company X implemented a practice Y from the WAVE model besides the company X itself and the 2DAM-WAVE evaluator.

A. Mini Evaluation Dimension

The WAVE mini evaluation aims to conduct a rapid initial evaluation about the capability a unit from an organization in GSD, and enable it to compare with other units already evaluated.

This mini evaluation is entirely online, and held by a support tool [21]. It has as main characteristic, not require the intervention of any GSD or WAVE expert to calculate the results. We chose to collect data in the mini evaluations using questionnaires, as this method enables the capture of highly structured data and can be handled without human intervention [22]. Furthermore, it is always available for the interested units and does not require any prior knowledge of the WAVE capability model [23].

The process of the mini evaluation dimension for WAVE is divided into three main phases, namely: "Prepare and Plan the Evaluation", "Conducting the Evaluation", "Results Report". These steps are illustrated in Figure 2.
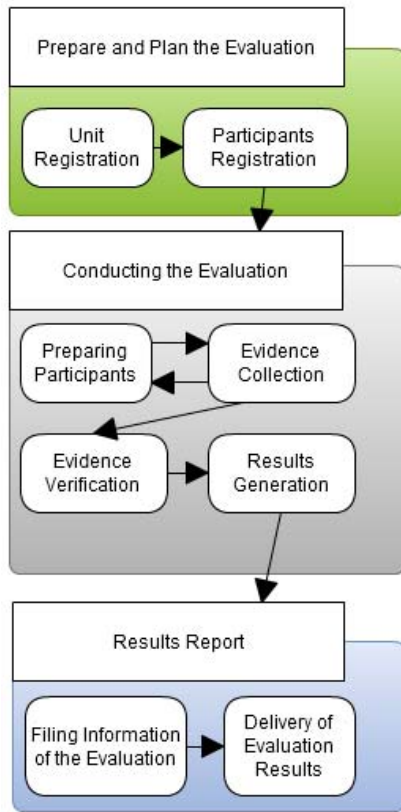
FIGURE 2 – MINI EVALUATION PROCESS

To undergo a mini evaluation, at the "Plan and Prepare the Evaluation" phase, the unit needs to register in the support tool and answer a series of questions about its profile, such as number of employees and experience in GSD. If the unit already has the profile and, therefore, has already been assessed by one of the 2DAM-WAVE dimensions, it can remake the evaluation as many times as necessary. This possibility allows a unit to improve its processes over the time without much effort. This practice is commonly used in process improvement programs [24].

Once logged on, the unit must select six users to participate in the mini evaluation by responding to questionnaires. It is known that evaluations that use only questionnaires to collect data, are highly dependent on the opinion of those who answered them [25], so the evaluation uses two groups of professionals, three with technical responsibilities and three with management responsibilities. Thus, through a heuristic, we seek to reduce the impact of extreme views within the groups and see if the perceptions about the unit capabilities are uniform in both groups.

It is important to outline that the users chosen to answer the questionnaires should have GSD experience and work in relevant projects for the unit. In the context of this evaluation, a relevant project is distributed and is representative for the unit in financial terms, processes used and team size.

It is during the phase of "Conducting the Evaluation" that respondents, who were registered by the unit, do the log-in in the supporting tool and respond to the questionnaire. The questionnaire has several questions, each of which represents an attribute of the WAVE capability model. Responses to questions are always equal to the implementation of a practice from the attribute asked. This approach facilitates the evaluation, because the response indicates, directly, the level of each attribute, and at the end of the questionnaire, the unit capability level. This mechanism works well because the WAVE practices are cumulative, i.e., " if the practice of number $X + 1$ of an attribute is considered implemented, then we know that the practice X also were." [8]. All questions and answers were submitted to the validation of two GSD experts, one being the WAVE author.

Some questions are not used in the questionnaire of the respondents belonging to the technical group, since some practices of the WAVE model are not relevant to this group. Attributes as "Project Allocation" are examples of this exception.

Respondents have no preset limit of time to answer the questions in the evaluation support tool. After all respondents finish filling the questionnaires, the supporting tool calculates through a heuristic, if the data collected are valid, or if there was any relevant discrepancy between the results. The heuristic check if more than 66% of the responses to each question were equal, if not the data is considered inconclusive. If the responses of at least one question are considered inconclusive by the heuristic, the respondents are invited to reach a consensus, responding once more to a questionnaire that contains only the questions with inconclusive answers.

Once approved by the heuristic, the data collected in the evaluation are recorded in the evaluation's database. Because the mini evaluation is simple and does not have the intervention of any expert in the WAVE model or in GSD, the result does not propose improvements. Like the SCAMPI C, its results are not considered sufficiently assertive, but they are considered as an indication of the supposed capability of the company in GSD [26]. On the other hand, it is possible to identify the strengths and weaknesses of the unit evaluated, showing its supposed GSD capability level and adherence to the capability levels that were not implemented.

During the "Report Results" phase, the evaluated data are entered by the support tool on a database that concentrates the data from evaluations already performed. From this database of historical data, the unit can be compared with other units through a series of reports that are provided by the support tool. It will be able, for example, to check the development of units in GSD by region, to discover what is the percentage of units at a certain level. These data will be available to the scientific community as well. These reports have been left for future studies, yet the data is structured in a way that is ready for consumption. After the end of the mini evaluation, the unit can access the results generated by the support tool any time.

The results of the mini evaluation are "Supposed Capability Level by Capability Area", "Supposed Capability

Level of WAVE", "Adherence by Capability Level" and "Adherence by Capability Areas." The first two types of result were inspired by SCAMPI C [26], whereas the latest two are based in MMGP [27].

The result "Supposed Capability Level by Capability Area" is calculated for any capability level in all capability areas of the WAVE model. The level is considered implemented if:

$$\frac{\text{Total number of practices in the capability area X in the level Y}}{\text{Number of implemented practices in the capability area X in the level Y}} = 1$$

If an area Y fails to reach the level X of the WAVE, it is known that none of the levels X or above may be considered as achieved in that area [8]. The result "Supposed Level of WAVE Capability" follows the same logic of the previous calculation, but it is general for the whole model. Its calculation is generated for all levels of the WAVE capability model. A level is considered implemented if:

$$\frac{\text{Total number of practices in the level X}}{\text{Number of implemented practices in the level X}} = 1$$

The result "Adherence by Capability Level" is a report that helps the unit to check how close it is to achieve a capability level X, in one of the capability areas. This calculation is also performed for any level in all capability areas, and its adherence is calculated as:

$$\frac{\text{Total number of practices in the capability area X in the level Y}}{\text{Number of implemented practices in the capability area X in the level Y}} * \frac{100}{X}$$

It is important to note that, even if a company has 100% adherence at a capability level X, this alone does not mean that the company is at level X. This becomes clearer, taking the example of a unit that has 100% of adherence at level 2, 80% adherence at level 3 and 100% adherence at level 4 of the WAVE. This would indicate that the unit currently has capability level two in WAVE, but by implementing the remaining 20% of practices left of level 3, it would become level 4 in WAVE.

Finally, the result "Adherence by Capability Areas" is not separated by capability levels. This allows the unit to verify the disparity of its capabilities between the different areas. The graphic generated is shown in Figure 3.
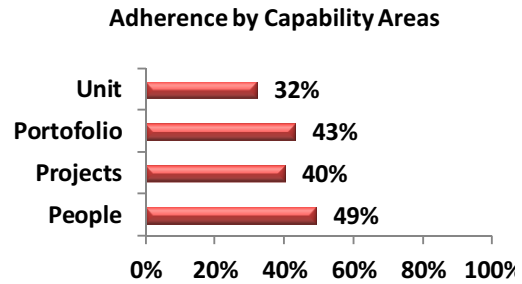

FIGURE 3 – ADHERENCE BY CAPABILITY AREAS

B. *Dimension of most extensive evaluation*

The dimension of the most extensive evaluation of WAVE tries to make a detailed evaluation about the unit capability in GSD. Unlike the mini evaluation, this dimension makes a depth analysis of processes and activities of the unit and uses an evaluation team specialized in GSD, the WAVE capability model and its method of evaluation. This allows the generation of improvement's proposals ordered by relevance. The phases of this extensive dimension are equal to the mini evaluation, but their activities change significantly. These activities are based mainly on the SCAMPI A [10] and MA-MPS [14] activities. The process of the most extensive evaluation is illustrated in Figure 4 and is detailed bellow.
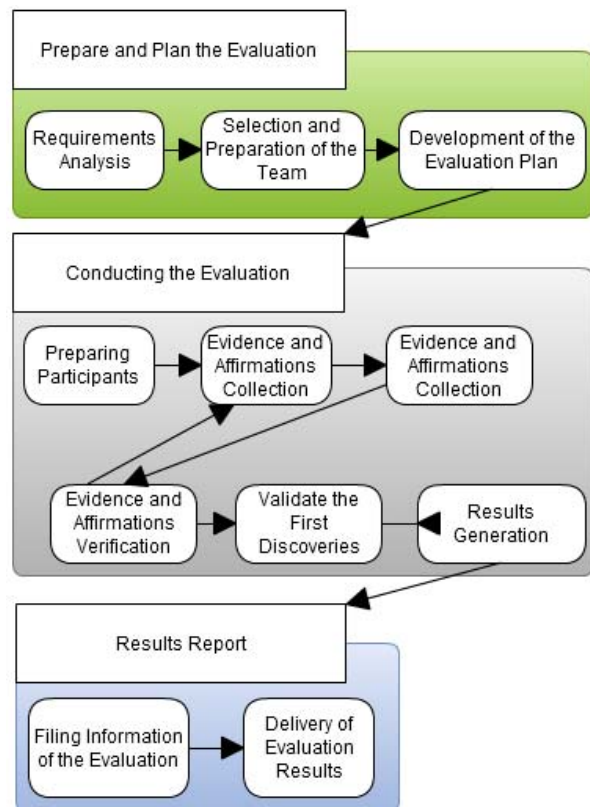

FIGURE 4 – THE MOST EXTENSIVE EVALUATION PROCESS

1) Prepare and Plan the Evaluation: This phase should be carefully performed to ensure an evaluation without critical problems [28]. It is composed of three activities: "Requirements Analysis", " Selection and Preparation of the Team" and "Development of the Evaluation Plan".

In the activity "Requirements Analysis", the unit accesses the supporting tool and registers its profile, if it is not done yet. The unit can then start the most extensive evaluation by getting in contact with one of the leading evaluators that are suggested by the supporting tool. Those suggestions are managed by the research group MuNDDoS. The evaluation's leader has the responsibility to conduct the most extensive evaluation, therefore he must have knowledge and experience in the WAVE capability model and in the evaluation method 2DAM-WAVE [29]. It is also in this activity that occurs the definition of the unit member that will perform the role of sponsor in the evaluation. Once agreed these roles, the sponsor shall present to the evaluation's leader, his unit, his business and the goals of the evaluation.

During the activity of "Selection and Preparation of the Team", the internal evaluators are chosen to compose the unit evaluation team. It is recommended to use at least two internal evaluators, who should have experience in GSD, knowledge about the processes of the unit and experience in relevant projects of the unit that is being evaluated. These evaluators add quality to the evaluation, providing quick access to documents and people from the unit [28].

The evaluation's leader will register these evaluators in the support tool. The tool will send an e-mail, informing the internal evaluators about their new responsibilities and indicating a must-read material that summarizes GSD, the WAVE capability model and its evaluation method. Finally, it is held a kick-off meeting with the evaluation team and the sponsor. At this meeting, the evaluation's leader should make sure that the internal evaluators understood the concepts presented in the material shown giving a small training about GSD, WAVE, and 2DAM -WAVE.

In the last activity of this phase, "Development of the Evaluation Plan", occurs the identification of the projects that will be used for the evaluation. It requires the use of two projects, one recently completed and another in the final stages of development. This ensures that at least one project has passed through all stages of development and the other is still with the assembled team, facilitating access to the professionals and to the project documents [30]. The projects selected must be representative to the unit and relevant for the evaluation [14], therefore the projects is distributed and is representative for the unit in financial terms, processes used and team size. [10]. The scope of this dimension covers the entire WAVE model, since its complexity is not as big as in other quality models such as CMMI models or MPS.BR, which justifies reduced scope evaluation.

Once determined the projects to be evaluated, the "Evaluation Plan" should be completed. This document contains plans for collecting evidence and affirmations, the evaluation schedule, its deliverables, among others topics. It is written by the evaluation's leader with the aid of the internal evaluators. The evaluation's planning is very important to avoid critical problems during the evaluation [28]. Once completed, the document can be reviewed by the evaluation's sponsor and signed.

2) Conducting the Evaluation: This is the phase in which all collected evidence and affirmations are made, the calculations on the capabilities of the unit are done and also where improvements, strengths and weaknesses are identified. The activities of "Preparing Participants", "Evidence and Affirmations Collection", "Evidence and Affirmations Documentation", "Evidence and Affirmations Verification", "Validate the First Discoveries" and "Results Generation" are detailed below.

The activity of "Preparing Participants" is used to contextualize the professionals who will participate in the evaluation. These people are mostly those that were selected in the previous phase to be interviewed. This activity can be completed by registering in the supporting tool the e-mails of the evolved professionals. The tool then sends an e-mail, presenting the evaluation and its objectives.

During the "Evidence and Affirmations Collection", the evaluation's leader conducts the planned interviews in the "Evaluation Plan" using the "Base Interview's Questions" as an aid. This artifact partially structures the interviews through a tariff, helping the evaluator to approach all the WAVE practices [28]. These interviews are conducted with technical professionals groups or management professional groups. For the interviews not become unproductive, it should not take more than one hour. To optimize the time available, the interviews should be recorded, releasing the evaluator with the responsibility of writing down the answers. It is important to note that the content of the interviews is not equal for the group of technical professional and for the management group. That distinction is for the same reason that the mini evaluation has different questionnaires for these two groups. In the end, the results of the interviews can generate, for each WAVE practice, positive affirmations, weaknesses points, relevant weaknesses points and improvements suggestions.

While the evaluation's leader conducts the interviews, the internal evaluation team prospects evidence of the practices implementation in their unit. This search is guided by the "List of Expected Evidences", which lists which artifacts and tools are typically expected to consider a practice implemented. After the completion of this analysis, the leader evaluator meets with the internal evaluators, and together they verify which found evidences are considered valid. Evidences which not apply are not excluded, as they may be used during the generation of improvements proposals. This data source can generate, for each WAVE practice, implementation evidences, weaknesses points and relevant weaknesses points.

In the activity "Evidence and Affirmations Documentation" both data sources, interviews and evidence analysis, should be consolidated in the "Evidences and Affirmations Spreadsheet of the Project." The recorded interviews and analyzed documents should be reviewed and compiled into affirmations, positive evidences, weak points, relevant weak points and possible improvements.

There are always two evidence and affirmations spreadsheets in this time of the evaluation, one for each project evaluated, defined during the evaluation planning.

It is in the activity "Evidence and Affirmations Verification" that the evaluation's leader verifies if the data collected from the two sources indicate the same result. Furthermore, the leader evaluator identifies if evidences or affirmations of a particular practice were forgotten or are insufficient for one of the projects evaluated. Then the result of the analysis is shared with the internal evaluation team and it is discussed the necessity of a complement in the evidence or affirmations collection already made. If a new collection is considered necessary, the "Evaluation Plan" should be changed and the evaluation process returns to the activity of "Evidence and Affirmation Collection".

In the activity "Validate the First Discoveries," begins the verification of implementation of the WAVE practices for each of the projects evaluated. To be considered implemented a WAVE practice requires a positive affirmation and, when indicated by the "List of Expected Evidence," one valid evidence must also be found. Moreover, the practices implemented should not have any relevant weak points.

The evidences are not mandatory for all practices, as many of these can only be proved by the affirmation of a professional. The CULT1 WAVE practice is an example: "The employees understand that there are cultural differences and informally share tips on how to deal with them". The evaluation criteria are shown in Table 2.

TABLE 2   EVALUATION CRITERIA

Level of implementation	Characterization
Fully Implemented	- (1-n) Valid Evidence - [1-n] Positive affirmations - [0] Weak points - [0] Relevant weak points
Widely Implemented	- (1-n) Valid Evidence - [1-n] Positive affirmations - [1-n] Weak points - [0] Relevant weak points
Partially Implemented	- (1-n) Evidence - [1-n] Positive affirmations - [1-n] Weak points - [1-n] Relevant Weak points
Not Implemented	- (0) Evidence - [0] Positive affirmations - [1-n] Weak points - [1-n] Relevant Weak points

The levels of implementation "Fully Implemented" and "Largely Implemented" indicates that the practice was considered implemented. The level of "Partially Implemented" indicates that practice is not accepted, but that it would be accepted if it had no relevant problems. Finally, the grade "Not Implemented" as the name suggests, are not considered to be implemented and there is no record of the unit's efforts to implement it.

After discovering the unit's projects capability, the level of the unit as a whole is verified. Therefore, the leader evaluator should consolidate the two projects evaluation spreadsheets in the "Unit Evaluation Spreadsheet". This spreadsheet consolidates the evaluation of both projects by applying for every practice the capability of the project with the lowest level of capability. The points at which the projects evaluated had different levels of capability are used, by the evaluation's leader, to propose improvements to the unit.

At last, the entire evaluation team uses the data obtained during the evaluation to make the "Evaluation results document." It has the capability results of the unit's projects and the unit as a whole. It also has a list of strengths and weaknesses of the unit and a list of suggested improvements prioritized according to the unit goals.

To assist in the prospection of improvements to the unit, the evaluation team should check the following data collected during the evaluation: weak points of practices' implementation by the projects, suggestions gathered from the professionals during the interviews, discrepancies of capability level between the unit's projects and the analysis on the adherence of the different WAVE capability in the unit. The evaluation's leader experience not only in GSD but also in the WAVE capability model should assists in this process.

3)   Results Report: In this phase of the evaluation results are presented to the unit and sent to the MuNDDoS database. The activities "Filing Information of the Evaluation" and "Delivery of Evaluation Results" are detailed below.

In the activity "Filing Information of the Evaluation", the results obtained in the previous phase and all relevant artifacts are included in the WAVE's database of historical data. The artifacts considered relevant are: the unit's evidences and affirmations sheets, the results of the evaluation and the evaluation plan. The evaluation's leader performs the upload of these documents in the support tool for the evaluated unit may access this information in the future.

In the last activity, "Delivery of Evaluation Results", the leader of the evaluation presents to all stakeholders, the results obtained. Finally, the evaluation team uses the support tool for registering the lessons learned and improvements to the evaluation method 2DAM-WAVE. These improvements and lessons learned will be used by MuNDDoS to evolve the process and the support tool.

V.   EVALUATION RESULTS

Table 3 summarizes the results of the evaluation of the mini evaluation held at the Brazilian unit from organization A.

TABLE 3   MINI EVALUATION RESULT

Brazilian Unit from Organization A Mini Evaluation			
	Existing Practices	Implemented Practices	Proportion
People	29	24	88%
Level 2	17	16	94%
Level 3	10	7	70%
Level 4	2	1	50%
Projects	29	29	100%
Level 2	11	11	100%
Level 3	9	9	100%
Level 4	8	8	100%
Portfolio	11	11	100%
Level 2	5	5	100%
Level 3	4	4	100%
Level 4	2	2	100%
Unit	6	6	100%
Level 2	2	2	100%
Level 3	2	2	100%
Level 4	2	2	100%

Table 4 summarizes the results of the most extensive evaluation conducted in the Brazilian unit from organization A.

TABLE 4   MOST EXTENSIVE EVALUATION RESULTS

Brazilian Unit from Organization A Extensive Evaluation			
	Implemented Practices	Proportion	Improvements Proposed
People	29	93%	
Level 2	16	94%	13
Level 3	9	90%	
Level 4	2	100%	
Projects	29	100%	
Level 2	11	100%	5
Level 3	9	100%	
Level 4	8	100%	
Portfolio	11	100%	
Level 2	5	100%	
Level 3	4	100%	
Level 4	2	100%	
Unit	6	100%	
Level 2	2	100%	1
Level 3	2	100%	
Level 4	2	100%	

For the evaluation result is noticed that the unit has a high capability in global software development. However, even implementing the various practices of the WAVE capability model, the most extensive evaluation has generated a significant amount of suggestions for improvements to the unit. This high capability of the unit evaluated in GSD was expected, as the unit is used to work in this context for almost 10 years and It was also one of the units who helped to create the WAVE model. Organizations who are not mature in the GSD context should have even better benefits from evaluations like this.

As this was the first evaluation of 2DAM-WAVE, the unit evaluated cannot be compared with the market or with other units of the organization.

VI.   RESTRICTIONS

Because of the chosen research method, a case study, this research presents normal limitations in qualitative studies. The main limitation is related to generalization of results, since only one case study was applied. For that matter, we cannot say that the 2DAM-WAVE does not need adjustments to be applied in other organization.

Furthermore, the support tool has not been tested and used outside the controlled environment of the case study. This means that there may be flaws in it and these may appear as new organizations seek the 2DAM-WAVE to perform capability evaluation.

Finally, the WAVE capability model should be improved for the 2DAM-WAVE evaluation becomes more assertive.

VII.   FUTURE WORKS

There is an opportunity to apply the WAVE and 2DAM-WAVE in more organizations in 2012. These evaluations would assist in the WAVE and 2DAM-WAVE maturation through acquired experience and feedback collection. This work would ease the main limitation of this research and WAVE, which was the capability to generalize. Moreover, this work would allow the academic community to understand better which are the main GSD difficulties within the organizations nowadays.

Moreover, the support tool will be expanded to provide features such as GSD benchmarking. These features will increase the value of 2DAM-WAVE evaluations creating more incentive to conduct further evaluations in other organizations.

VIII.   FINAL CONSIDERATIONS

This research has added value to the GSD area proposing an evaluation method for the WAVE capability model. The WAVE-2DAM also improves the WAVE capability model, enabling it to be applied in the industry or academy. Furthermore, the proposed support tool, allows researchers to verify the evolution of GSD capability over time, improving the perception of the academy about what is occurring in the industry.

The industry also will be benefited by this research, because, with the 2DAM-WAVE, companies can be evaluated obtaining improvements suggestions and discover their capability in GSD. Furthermore, the evaluation support tool will provide a good practices repository so companies that are trying to improve their processes in GSD can have ideas of how to evolve. The industry is also benefiting from the support tool developed in this research, since it enables mini evaluations with no cost to the unit concerned and facilitates contact with GSD experts. Furthermore,

organizations may, with the 2DAM-WAVE, verify if all units have a common capability for GSD and identify bottlenecks and opportunities for improvement in their units.

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