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QUALITY MANAGEMENT AS A COMPETITIVE STRATEGY IN A DISTRIBUTED SOFTWARE DEVELOPMENT ENVIRONMENT[1]

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Abstract

This paper presents an exploratory case study on the SW-CMM (Capability Maturity Model for Software) Level 2 certification process by an offshore software development center, located in Brazil, belonging to Dell Computer Corporation. The objective of this paper is present the main Lessons Learned in this research. Also, it presented the importance and the impact in the inter-organizational relationship. Finally, it is identified the main difficulties and critical factors of success in the implementation of the SW-CMM in a DSD environment.

Keywords: Software quality management, distributed software development, software process improvement, strategy, SW-CMM

Introduction

The dramatic changes in the contemporary world resulting from an increasingly globalize economy, swift and devoted to competition, are progressively obliging large companies to search for alternative ways to increase their productivity, reduce costs and improve the quality of their products. One growing strategy among these companies is the distribution of software projects to offshore development centers located in countries such as India, Brazil and Russia.

Recently, the improvement model based on the concept of maturity of software processes, the SW-CMM, has been used by many offshore organizations as a tool to improve their software development processes, increase productivity and the quality of their products, and legitimize themselves with their head offices as capable and reliable software development centers.

In January 2001, Dell Computer Corporation one of the biggest North-American company in the IT sector set up its first offshore software development center in Brazil. The Global Development Center (GDC) was the company's first experience in offshore development, that is, in transferring the development of their internal systems on a large scale to other countries, something that was entirely done in the United States before. The GDC was created for the purpose of meeting the demands for systems of the Dell business units around world. Brazil, together with India and Russia, was selected to meet this demand.

Aiming at achieving an appropriate strategic position with their head office, the directors of GDC Brazil decided to implement the software improvement model named as SW-CMM so as to differentiate and leverage the capacity of execution of their software projects.

Background and Context

Strategy

Strategy can be defined as "the pattern or plan that integrates an organization's major goals, policies, and action sequence into a cohesive whole" (Mintzberg 1996). A company may possess two types of competitive strategy: (1) low cost, or (2) differentiation. Competitive strategy is a function of either providing comparable buyer value more efficiently than competitors (low cost), or performing activities at comparable cost but in unique ways that creates more buyer value than competitors (differentiation) (Porter 1986). In this way, large corporations seeking to identify opportunities and obtain competitive advantages through the utilization of IT have utilized the software quality assurance area.

Software Quality Assurance

Software Quality is defined as the "Conformance to explicitly stated functional and performance requirements, explicitly documented development standards, and implicit characteristics that are expected of all professionally developed software" (Pressman 2001). There is a series of solutions (rules and certifications) internationally recognized, such as ISO, CMM and SPICE. The CMM has been regarded as the most consolidated and applicable software quality model (Pressman 2001). The Capability Maturity Model for software is a framework that describes an evolutionary improvement path for software organizations from an ad hoc, immature process to a mature, disciplined one. This path encompasses five levels of maturity that covers practices for planning, engineering, and managing software development and maintenance (Paulk 2001). These five maturity levels define an ordinal scale for measuring the maturity of an organization's software process and for evaluating its software process capability. The levels also help an organization prioritize its improvement efforts (Paulk et al. 1993).

Distributed Software Development

As part of the globalization efforts currently pervading society, the software project teams have also been geographically distributed in worldwide. This characterizes Distributed Software Development (DSD). When the stakeholders involved in the process are globally distant, it's characterizes a kind of DSD, called Global Software Development (GSD) (Herbsleb *et al*. 2001). The companies that adopt its strategy seek competitive advantages in terms of costs, quality and flexibility in the systems development area. The concepts of *outsourcing* and *offshore outsourcin*g arise when a company chooses to set up a development environment that is physically distant from their head office. Outsourcing is the practice of hiring an external organization to develop a system, instead of developing it in-house (McConnel 1996). One of the options of outsourcing, which is becoming very popular over the last years is the offshore outsourcing. Offshore organizations are companies located in some other country that offer lower development costs with quality comparable with the quality of organizations based in their own country (McConnel 1996).

Organizations sometimes assume that if someone else builds the software for them, their job will be much easier. But the reality is almost the opposite (McConnel 1996). Within the context of global IT outsourcing, there is lot of factor that influence in the success of the relationship between offshore units and its head office. On most global teams, frustrations outnumber successes. The major challenges that can cause the downfall of global teams is to manage cultural diversity, differences, and conflicts; handling geographic distances, dispersion, and despair; dealing with coordination and control issues; maintaining communication richness over distances, developing and maintaining teams (Marquardt 2001).

Research Method

Characterization of the Organization

The organization researched is the offshore software development center (the GDC, mentioned before) located in the South of Brazil, belonging to Dell Computer Corporation. This center was created based on the incentives of Brazilian Federal Law No.

8.248/91, which provides that companies producing computer goods and services invest at least 5% of their revenues in research and development activities in the country. When GDC was set up in January 2001, it had 20 employees. Now, it relies on over 110 professionals working on over 25 software projects. Figure 1 shows the present organizational structure of GDC, highlighting their development areas (one devoted to legacy systems and one to new technologies). GDC operates in a DSD environment (Figure 2), and it is one of the offshore software development centers of the researched company. The other centers are located in India and Russia. The company has made a lot of effort to implement a Software Process Improvement (SPI) based on SW-CMM practices as a way to leverage the quality and reduce the costs in IT.

Figure 1. GDC Organizational Structure

Figure 2. Distributed Software Development

GDC operates in a DSD environment (Figure 2), and it is one of the offshore software development centers of the researched company. The other centers are located in India and Russia. The company has made a lot of effort to implement a Software Process Improvement (SPI) based on SW-CMM practices as a way to leverage the quality and reduce the costs in IT.
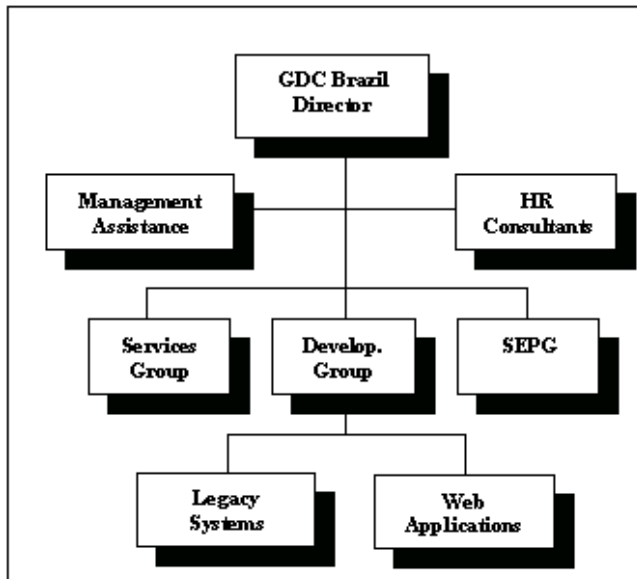
Research Method and Collection and Analysis of Data

This research is characterized predominantly as an exploratory study whose main research method was the case study, as proposed by Yin (1993). The use of qualitative methods in this research can be justified by the fact that it involves the study of a SW-CMM implementation process in its real context, aiming at documenting and analyzing the results of a practical experience (Yin 1994). For data collection, a multi-method solution was adopted – questionnaires, interviews, surveys, and experiences lived. This diversity of data sources enabled the triangulation of the information found, therefore increasing the reliability of the results (Yin 1993).

Three interviews were made with some project directors and managers, utilizing the free narrative and the semi-structured techniques (Yin 1993). For the validation of results a content analysis was developed, with replicability and stability test (Krippendorff 1980).

A longitudinal survey was also conducted, which was applied in two moments of the process. It was developed a questionnaire consisting of 50 questions covering the Software Development Process areas (11 questions); Software Quality (7 questions); Organizational Culture (19 questions) and questions related to the KPAs of SW-CMM Level 2 (13 questions) (Table 1). Face and content validations (Hoppen 1997) were carried out by two experts in the area of Information Systems and 3 employees from the GDC, being one from the Development area and two from the Software Quality area. In total, 3 pre-tests were made until the questionnaire to be applied became stable.

Table 1. Type of Questions Applied Through the Survey

Type of Questions / Related area	Software Development Process	Software Quality	Organizational Culture	SW-CMM Level 2 KPAs
Direct	2	4	4	3
Perception	2	2	11	10
Indirect	7	1	4	0
Total	11	7	19	13

Population: 90
Non-response: 17 (18%)

The research team has also followed all the activities and events of the certification process, acting together with the Software Engineering Process Group (SEPG) of the GDC, therefore experiencing all the process in practical terms. Among the events followed and recorded by the researchers, the Mini-Assessment, the SQA audits, the Self-Assessment, the Software Capability Evaluation (SCE) course and the Official Assessment should be highlighted, as well as all the training and improvement courses that have been developed and hired.

Two strategies had been used to analyze the collected data. The first one was the document revision and analysis with the purpose to organize chronologically the main events involved in the certification process (Yin 1994). The second strategy was to use a tool (Sphinx) to make the analysis and to crossing the answers of the questionnaires.

Description of the GDC Software Process Improvement

From the strategy defined by GDC's directors to utilize quality management as a competitive tool in the outsourcing corporate environment (GSD), the necessary actions to achieve their objectives began to be defined. The first action taken was the selection of CMM as a reference model to be adopted in the software quality area. In this way, the implementation process of KPA's from SW-CMM Level 2 started in March 2001. The outline below (Figure 3) illustrates the set of phases that were considered relevant for the implementation of a software improvement model as a competitive strategy for a DSD environment. The scheme is based on the experience lived by GDC and involves the phases from the conception of the process to its conclusion, with the final assessment.
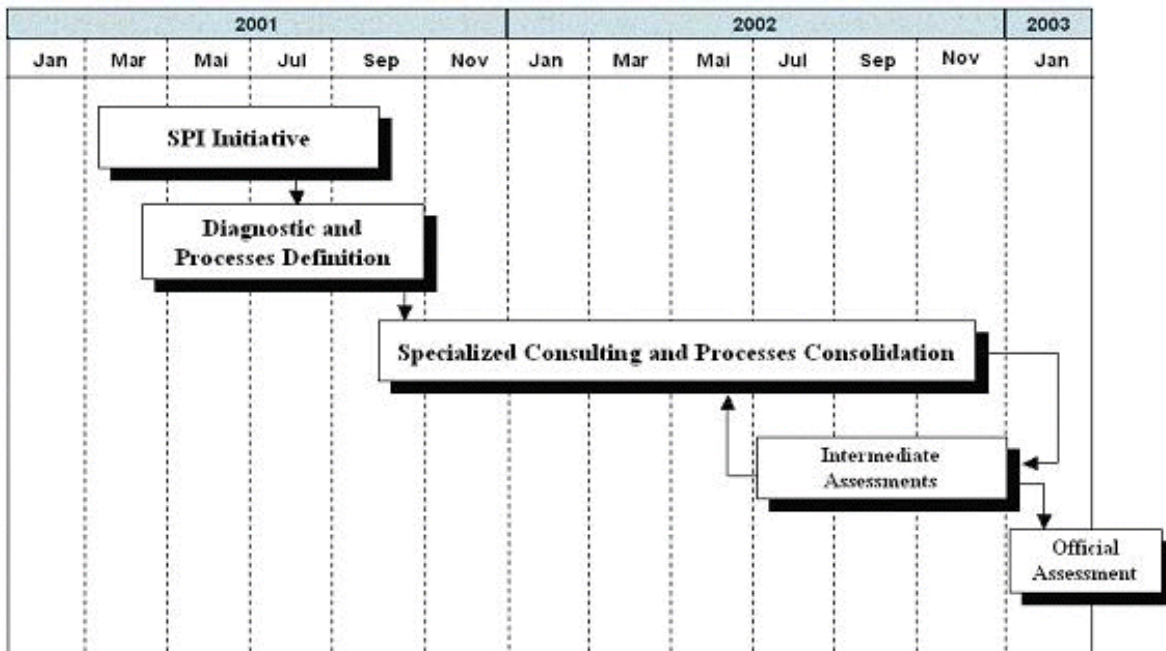

Figure 3. Software Process Improvement and Certification Phases

Phase I - The Software Process Improvement Initiative

This phase went from March to August 2001 and was mainly characterized by the hiring of a group of professionals commissioned to lead the SW-CMM implementation process in the GDC. This group comprised the GDC's SEPG, suggested by the SW-CMM (Level 3). The first task of the group was the acquisition of the necessary theoretical and practical knowledge for the implementation and management of the process in the GDC. The theoretical knowledge on the SW-CMM practices was acquired through specialized courses in the Software Quality area, which were held in a university of the region in association with the European Software Institute (ESI). It involved about 200 hours of training about the SW-CMM and its key areas.

Phase II – Diagnostic and Process Definition

This phase (April to September 2001) occurred at the same time of the initial training phase and started with the conduction of a diagnosis through the application of a questionnaire which was drafted based on the SW-CMM Level 2 practices aiming at identifying the current maturity level of the software development process of the GDC. Based on the diagnosis results, the SEPG members, along with the work teams (Program Action Teams – PATs) started the definition of the first version of the processes. The first process to be defined was the Software Project Planning (SPP). After that, it was defined the Requirement Management (RM), Software Project Tracking and Oversight (SPTO) and mapped the KPAs of the Software Configuration Management (SCM) and the Software Quality Assurance (SQA).

Phase III – Specialized Consulting and Process Consolidation

From October 2001 to November 2002, it is considered the phase of stabilization of the processes. The set of the first version of all the processes, procedures and templates defined by GDC, organized according to the SW-CMM KPAs, was called *Alpha Version* and made available to the employees through the company's intranet in an environment denominated *GDC Quality Framework* (GDC QF).

An important organizational change occurred during this phase, which posed a great challenge: as the result of the increase in demand for projects from the head office, the number of GDC employees increased from 20 to 60 in only three months. Strategies were taken during this phase. The Brazilian branch of a North-American consulting company with large experience in the CMM certification process was hired in order to speed up the process, in conjunction with a Brazilian university. Another important strategic decision made was the definition of the GDC Strategic References, including Mission, Strategic Purpose, Principles, Organizational Policies and Software Development Policies. This decision was made based on the results of the survey carried out by the research group in September 2002, which identified that up to that moment, the SDC staff saw software development Policies as something which was not connected with the processes and the objectives of the organization.

Phase IV – Intermediate Assessments

This phase went from June 2002 to January 2003. Aided by the consultants, the GDC created a Key Practices Action Plan and an official SPI Plan, which provided, in addition to training, 2 informal assessments (Mini-Assessment and Self-Assessment), and an external SQA Audit and the Official Assessment. In addition, a survey defined by the research group was carried out.

In line with its software process improvement initiative, in October 2002 the GDC performed a mini-assessment conducted by external consultants. The purpose was to compare its actual processes with the practices of CMM level 2. An Activity Improvement Plan addressed the process' weaknesses found out during the Mini-Assessment. Still in October, a gap analysis of the process documents was carried out. The Gap Analysis was conducted by SEPG from India's GDC in order to identify the gaps in Brazil GDC's Software Process Improvement. In December 2002, 8 GDC employees and 2 members of research team were trained in the official SCE assessment method. In December 2002 a simulation of the official assessment was carried out at GDC using the SCE appraisal method. Almost all weaknesses and gaps found out in the Mini-Assessment were solved at this time. Still in December, GDC held an Independent Assessment of Work Products and Activities from its SQA team.

As part of the research project, a longitudinal survey was carried out in September 2002 and January 2003, aiming at following the evolution of the knowledge acquired by GDC employees along the certification process. As a result of the aforesaid survey, a data analysis report was made for providing GDC managers with information that contributed to the success of the process.

Several training actions were taken based on the results presented in the report to support actions to ensure the obtainment of the certification.

A peculiar characteristic of this project was the high number of training and group dynamics developed during the consolidation and assessment phases. The project management, interpersonal relations, and other non-technical aspects (soft skills) should be highlighted. 26 courses were developed, totaling over 2,000 hours of training, represented by over 30 hours/man in the period.

Phase V - Official Assessment

The last phase of the process involved the GDC's official assessment carried out from the January 27th to January 31st 2003. The assessment was conducted by professionals from the consulting company, in conjunction with professionals from GDC and the associated University, skilled in the official assessment method (SCE V3.0). The objective of the assessment was to verify whether the practices of the SW-CMM Level 2 had been fulfilled, as well as to identify opportunities for the sequence of the improvement process by verifying the KPAs of Level 3. During a week, 4 software projects selected from the legacy systems and the new technologies areas were evaluated by means of questionnaires, document reviews, presentations, individual and group interviews.

The final product of the assessment was a set of findings related to all key areas of the Level 2 of maturity and the classification (achieved, not achieved, not applicable) of each component of the investigated model. On the last day, the assessment team made a presentation to all GDC employees, with the final findings of the assessment containing the strengths, the weaknesses, improvement activities, alternative practices, and the final result. In the 5 KPAs of Level 2 that were evaluated, it was found a zero degree of nonconformity, and therefore GDC Brazil was considered an organization with Level 2 of maturity.

Lessons Learned

In spite of being an offshore software development center that has been recently set up (two years), when we examine how the head office and its Brazilian branch conceived and conducted the implementation of Brazil GDC, we can infer a series of lessons that were learned in this research. We highlight below some of the lessons learned in this research process (Table 2), as well as the main difficulties and critical factors of success that led Brazil GDC to succeed in the strategy adopted.

Table 2. Lessons Learned

LESSON LEARNED	DESCRIPTION
1	Quality management is an important competitive advantage in organizations with geographically distributed software development centers.
2	Policies related to the software development process must be inserted in a corporate strategic context.
3	A strong managerial attitude, based on a defined strategy, with clear objectives, minimizes problems resulting from significant increases in the number of employees over a short period of time.
4	Staff commitment on all levels (direction, management, and operations) is paramount both at the local and corporate (head office) level.
5	Non-technical aspects (soft skills) of the software development process are critical to quality management. Unconventional solutions in the communications and motivation areas can yield satisfactory results.
6	Internal communication between offshore centers and corporate head office must be planned and implemented in a clear and transparent way.
7	Partnerships with specialized consulting companies and research centers (University) may contribute to the process.
8	Intermediary and periodical assessments (both internal and external) contribute to maintaining the course of the software improvement and certification process.

Lesson 1: Quality management is an important competitive advantage in organizations with geographically distributed software development centers

During the process, it became clear how important obtaining the certification would be for Brazil GDC. After the effective implementation of the strategy defined by the direction in the middle of 2001, there was a growing awareness of the importance of this strategy for the future of the Brazilian center. Internally (intraorganizational level), the improvement process in the software area engaged all the staff in an incremental way, even during the periods of largest growth at GDC. The constitution of a global team (Global SEPG) for the quality area, encompassing the head office and the offshore centers in India, Russia, and Brazil, can be clearly associated with the efforts from the Brazilian center, which was the first one to obtain the certification (even considering the North-American head office). In the words of the IT Vice-President of the company, who has just been to the country to define the continuity of the SPI at a global level, the Brazilian center stands out exactly for the quality and capability of the staff.

Lesson 2: Policies related to the software development process must be inserted in a corporate strategic context.

In the effort of the certification process, GDC defined a set of specific policies for the software development process, segmented by KPAs, as recommended by the adopted model. These specific policies for each key area were defined in the "void", since up to that moment GDC had no strategic references explicitly defined. The first phase of the survey developed by the research team clearly indicated the lack of strategic references on the part of the employees as whole. The dynamics for the definition of strategic references (Phase III) yielded a very positive effect in the whole team, with an increase in the personal motivation levels and a feeling of effective participation in the process of GDC strategic decisions. This undoubtedly shows that, in order to be sustained, the software development policies must be inserted in a corporate strategic context.

Lesson 3: A strong managerial attitude, based on a defined strategy, with clear objectives, minimizes problems resulting from significant increases in the number of employees over a short period of time.

One of the most critical moments during the certification process was the increase in the number of GDC's employees (Phase III). This represented a great challenge, in turn of the processes needed to be reviewed to accommodate the new structure of the organization and these new employees needed to soak up the organizational culture still under development, in a short period of time. The performance of GDC's directors and managers was decisive to ensure that the newly hired professionals rapidly fitted in the context. SEPG and the managers devised an intensive training plan that involved both the senior staff and the newly hired staff aiming at training them to utilize the procedures and templates available in the GDC QF and in the SW-CMM practices.

Lesson 4: Staff commitment on all levels (direction, management, and operations) is paramount, both at the local and corporate (head office) level.

One of the results that the first survey showed was that, in general terms, all GDC employees were committed to the process since its initial phase. One of the questions in the questionnaire aimed at identifying who, at managerial and strategic level, in the employees' perception, was supporting GDC the most in the pursuit of the SW-CMM certification. This question presented a desirable dispersion of answers, being that GDC's directors stood out as the ones who were supporting the process the most (20%), followed by the immediate managers (17%). From the actions developed after the survey, it was perceived a significant rise in the interaction among the directors of GDC Brazil, GDC India, and the North-American head office. During the process, as the commitment grew, the distension of the organizational climate was clear, reaching its climax with the presentation of the official assessment result.

Lesson 5: Non-technical aspects (soft skills) of the software development process are critical to quality management. Unconventional solutions in the communications and motivation areas can yield satisfactory results.

One of the factors that contributed to the success of the strategy was the emphasis given by GDC on non-technical aspects of the process. Several training and group dynamics were held in several moments of the process, aiming at integrating and motivating GDC's staff. Games, theatrical performances, and group dynamics conveyed the company's concern about the complete insertion of its employees in the certification process. An alternative adopted to ensure the success of the company's strategy was the execution of an internal marketing campaign called *Endomarketing Campaign*. As described in the Software Improvement and

Certification Process, it became clearly noticeable that, as the phases were taking place, alternative ways of engaging and integrating the teams were being utilized, exploring non-technical aspects (interpersonal relations, context, cultural differences, etc.).

Lesson 6: Internal communication between the offshore centers and corporate head office must be planned and implemented in a clear and transparent way.

One of the negative aspects identified by the first survey was the existing deficient communication on all levels of the organization, which reflected directly in the process. When GDC's staff was asked about the communication of the information related to the implementation of the software process improvement, they conveyed a negative perception. Only 41% of the total number of respondents considered the level of information received enough. This finding encouraged the development of a communication plan to reformulate the company's existing mechanisms and create alternative channels for passing on information. A North-American expert was hired to work on cultural and behavioral aspects of the software development process with geographically distributed teams.

Lesson 7: Partnerships with specialized consulting companies and research centers (University) may contribute to the process.

The hiring of a consulting company specialized in CMM was one of the factors that most contributed to the success of the GDC's strategy. The experience of the SW-CMM training and official assessment consultants was decisive on several occasions of the process. The creation of a SPI plan, with realistic targets and clearly identified risks, served as the guideline for the group during all the process. The partnership with a major university of the region and the effective participation of the researchers that recorded and analyzed all the process provided an external and exempt view of the process development. The usefulness of this kind of partnership was clear when the partnership agreement with the university was extended so as to maintain the same structure for SW-CMM Level 3.

Lesson 8: Intermediary and periodical assessments (both internal and external) contribute to maintaining the course of the software improvement and certification process.

GDC went through several preparatory assessments before the official assessment, as described in Phase IV of the software improvement and certification process. It was clearly noticed, both at managerial and operational level, that in each assessment conducted, new opportunities for improvement were revealed and the courses of action were corrected. This became clearer for the fact that in each intermediary assessment, the number of non-conformities found in the analyzed KPAs was being progressively reduced. This enabled the GDC to get to the official assessment very confident about the success.

Final Considerations

The results obtained in this research process sustained, according to the accounts presented in this paper, that quality management in the software area and the CMM certification may become an important competitive advantage in DSD. The data collected show that as the researched center improved its software development process, the number of projects allocated by the head office increased. The search itself for obtaining the certification generated a very important movement around the organization, with several visits from the Organization's top management, both from the head office and the other offshore centers.

In spite of not having been object of specific analysis during the study, a marginal finding points out an increase in the staff's self-esteem for having obtained the certification. It is speculated that the increase in self-esteem alone will generate positive effects with the project contracting parties. Certainly, the external image, both at local (it should be highlighted that the GDC Brazil was the first software company of the region to obtain the Level 2 certification) and national level (14th organization to obtain the Level 2 certification in the country), and even internationally (it is the first unit of the company to obtain the SW-CMM certification, whether in the United States or the other countries where it has offshore centers).

When we focus on the importance and implications of the achievement of the certification, as an offshore software development center, both objective and subjective aspects stand out. The objective aspects point to an effective improvement in the software

development process and the number of projects develop by GDC Brazil, which can be proved by metrics that show the increase in the number of compliances, both in relation to the software products developed and delivered and related to the process itself. In July 2002, when the SQA activities started, the average number of compliances was around 78%. Today, after the certification, this average increased to 97%. The number of project developed by GDC in March 2001 was around 5 projects; today GDC is working in 25 five software projects.

The subjective aspects may be seen from the improvement of the relationship between GDC Brazil and the head office, as well as with the other offshore centers. If we consider how recent the Brazilian software development center is, combined with the country's lack of tradition in this type of activity, we can establish a direct relationship between all the efforts towards the certification and the recognition from the corporate partners of the Brazilian center. Over the last two months, GDC was invited to participate as an active member of the head office's effort in establishing the SW-CMM as a global standard for the company in its worldwide centers. In addition, other offshore center of the company that is theoretically more advanced in the area (India) is adopting part of the GDC's processes as the basis for the definition of their own processes.

When we take into account the fact that the organization succeeded in achieving the proposed target, and supported by the research process that was developed, we identified that (1) the hiring of a specialized consulting company, (2) a clear and well defined strategic vision, (3) an intense training program determined by the needs identified along the process, and (5) the identification of actions, aiming to obtaining the participation and commitment of the staff, were the Critical Factors of Success encountered.

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