Six Sigma methodology based on the PMBOK guide in the release management process in software developer enterprise

Dacyr Dante de Oliveira Gatto
Master in Informatics and Knowledge Management
Institution: Universidade Nove de Julho (UNINOVE)
Address: Rua Vergueiro, 235 - 249, Liberdade, São Paulo – SP,
CEP: 01525-000
E-mail: dacyr.gatto@uni9.pro.br

João Rafael Gonçalves Evangelista
Master in Informatics and Knowledge Management
Institution: Universidade Nove de Julho (UNINOVE)
Address: Rua Vergueiro, 235 - 249, Liberdade, São Paulo – SP,
CEP: 01525-000
E-mail: joao.rafael@uni9.pro.br

Rosana Cordovil da Silva
Master in Informatics and Knowledge Management
Institution: Universidade Nove de Julho (UNINOVE)
Address: Rua Vergueiro, 235 - 249, Liberdade, São Paulo – SP,
CEP: 01525-000
E-mail: rosanacordovil@uni9.pro.br

Renato José Sassi
PhD in Electrical Engineering
Institution: Universidade Nove de Julho (UNINOVE)
Address: Rua Vergueiro, 235 - 249, Liberdade, São Paulo – SP,
CEP: 01525-000
E-mail: sassi@uni9.pro.br

ABSTRACT
The objective of this work was to analyze the application of the Six Sigma methodology based on the PMBOK guide in the release management process in a software developer company. With the increasing complexity of the release management process in the software developer company, we saw the need to analyze the mapped process, and identify points of failure or improvement that could be fixed/improved. For the implementation of the Six Sigma methodology, it was defined that the PMBOK would be used as the guiding basis for the definition of which project management processes would be used. The methodology was used as a reference for quality methods and tools for application in the process carried out by the application infrastructure area. A
qualitative approach was applied as a research methodology, with bibliographic research for the theoretical foundation and documentary research, making annotations about the observed process, as well as its results. By defining the project management processes, the project was executed in such a way as to provide the methodology to be applied assertively on the process, thus identifying the points of failure and improvement to be addressed, thus achieving the expected goal.

**Keywords:** Six Sigma methodology, PMBOK, management of release of version.

**RESUMO**

O objetivo deste trabalho foi analisar a aplicação da metodologia Six Sigma com base no guia PMBOK no processo de gerenciamento de liberação de versão em uma empresa desenvolvedora de software. Com o aumento da complexidade do processo de gerenciamento de liberação de versão na empresa desenvolvedora de software, viu-se a necessidade de analisar o processo mapeado, e identificar pontos de falha ou melhoria que poderiam ser corrigidos/melhorados. Para a execução da aplicação da metodologia Six Sigma, foi definido que o PMBOK seria utilizado como base de orientação para a definição de quais processos de gerenciamento de projetos seriam utilizados. A metodologia foi utilizada como referência de métodos e ferramentas de qualidade para aplicação no processo executado pela área de infraestrutura de aplicações. Como metodologia de pesquisa foi aplicada uma abordagem qualitativa, com pesquisa bibliográfica para a fundamentação teórica e pesquisa documental, efetuando anotações a respeito do processo observado, assim como seus resultados. Com a definição dos processos de gerenciamento de projetos, o projeto foi executado de forma a proporcionar que a metodologia fosse aplicada de forma assertiva sobre o processo, identificando assim os pontos de falha e melhoria a serem tratados, alcançando assim o objetivo esperado.

**Palavras-chave:** metodologia Six Sigma, PMBOK, gerenciamento de liberação de versão.

**1 INTRODUCTION**

Organizations seeking competitive advantages in a globalized and ever-changing market are challenged to pursue survival sustainably and with great speed in their strategic actions. Management and quality methodologies and good practices have offered opportunities for success according to the needs of the economic moment experienced by each organization.

The Six Sigma Methodology is a set of methods and tools designed to optimize process performance by listing defects or failures and non-conformities,
eliminating them, based on customer specifications. It was initially used by Motorola in mid-1987 but was popularized when GE (General Electric) adopted the methodology to assist in business management (Welch, 1999; Basu; Wright, 2003).

Motorola used a continuous improvement approach, based on Deming’s concepts, comparing the performance of the current process with the product specification, such as an effort to reduce defects/failures and other non-conformities. The Six Sigma methodology is a systematic strategy for quality and improvement programs and projects, aiming to achieve a high level of quality, whether of a product or process (Basu; Wright, 2003).

The Six Sigma methodology covers the identification of the current quality level as well as the occurrence of defects and failures. The tools used by Six Sigma are based on statistical tools and more specifically on methods and processes, seeking to achieve measurable goals, as well as increase productivity and efficiency, reducing waste, errors and failures, improving existing products and processes, based on logic, sequencing and structure for implementing improvement projects (Pande et al. 2000; Werkeman, 2002).

Within the context of the relationship between Six Sigma and projects, it is essential that they are selected according to the company's strategy, with clear goals and knowledge of the entire team. This link with business strategy is considered essential for increasing the efficiency and competitiveness of companies (Harry; Schroeder, 2000; Pande et al., 2000). In this way, in order to achieve success in projects, having a direction for the implementation of projects became important in all areas, whether products or services.

The growth of project management in Brazil can be seen in several ways. The penetration of the PMI (Project Management Institute), the main professional association dedicated to project management, for example. Founded in 1969, the PMI encourages the creation of local chapters as local sources for dissemination and as a critical mass of professionals.

Project management, therefore, is the application of knowledge, skills and techniques for the execution of projects in an effective and effective manner. It is
a strategic competence for organizations, allowing them to link project results with business objectives - and thus better compete in their markets.

The publication *Guide To The Project Management Body of Knowledge* can be regarded as a milestone in the history of project management. Better known as PMBOK, it is authored by the PMI or, more precisely, the PMI Standards Committee, the PMI standardization committee.

2 THEORETICAL FRAME

2.1 SIX SIGMA METHODOLOGY

Since its emergence, according to Gonçalves (2008), almost two decades ago, the Six Sigma methodology has been gaining appreciation from organizations as an approach to quality improvement with a positive impact on business performance. This consideration has given notoriety not only in the manufacturing industry, but also in service operations, showing that Six Sigma is within the scope of organizations' strategic discussions.

When it was broadcast by Motorola at the end of the 80s, Six Sigma had the purpose of being an initiative aimed at controlling total quality, with an emphasis on customer satisfaction and the elimination of errors and failures in the production processes. Since then, Six Sigma has evolved conceptually and has ensured more comprehensiveness, mainly regarding the managerial and strategic actions necessary for its implementation (Santos, 2010).

Also Trad (2009) and Santos (2010) corroborate that the focus on data and facts and the reported benefits on increasing the efficiency of production processes; reducing the costs associated with inspection, rework, customer dissatisfaction and waste; focusing on processes; continuous improvement; customer focus; culture change; drastic reduction of variation; and commitment made the topic attractive and raised curiosity and questions about its effective contribution.

The literature suggests that Six Sigma is a program that has brought contributions in several aspects to increase discussions on quality management and strategic management, based on the perception that its structure included
essential requirements such as: quality concept; combination of statistical and strategic approaches; methodological systematization to implement projects; specialist training; and project management (Gonçalves, 2008; Santos, Martins, 2010).

However, according to Santos and Martins (2010), there is still a certain scarcity in the literature of works that bring a practical vision about the relevance of these requirements for Brazilian companies, mainly in the context of service processes.

Originating from the Greek alphabet, the Greek letter \( \sigma \) (sigma) is also used as a mathematical symbol for the measure of variation. The term **Six Sigma** defines a quality measurement: 3.4 defects per million events or 99.99966% assertiveness. Any change that causes dissatisfaction can be considered a defect, such as a product or service that does not meet the customer's specifications (SIX SIGMA INSTITUTE, 2016).

The **Six Sigma Institute** (2016) states that in statistical terms, \( \sigma \) is a measure that quantifies the variation between the results of any process or procedure or product. The lower the value of the variation, the better and more precise the process is. It is used to measure the quality level associated with a process. The higher the value achieved on the sigma scale (1 Sigma, 2 Sigma, 3 Sigma), the better. When you have a Six Sigma process you can't get more than 3.4 defects per million results produced in a given process. Table 1 shows the members and responsibilities of a Six Sigma team, but it is important to note that a project may require all or only some of the qualifications depending on its characteristics.

<table>
<thead>
<tr>
<th>Six Sigma Team Members</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Champion (Sponsor/Leader)</strong></td>
<td>Responsible for implementing Six Sigma projects in specific companies or areas. They coordinate teams in the development of projects and prepare the way for the necessary changes and obtaining the results.</td>
</tr>
<tr>
<td><strong>Master Black Belts (Black Belt Leaders)</strong></td>
<td>Present in large companies, the Master Black Belts assist the Champions in identifying improvement projects, as well as coordinating all the work of the other members of the Six Sigma teams.</td>
</tr>
<tr>
<td><strong>Black Belt (Black Belt)</strong></td>
<td>They are the main actors in a Six Sigma project. They are dedicated, full time, to the project.</td>
</tr>
</tbody>
</table>
Green Belt (Green Belt) They are not entirely dedicated to solving the problems highlighted in the projects. They are designated according to their knowledge of the subject.

Yellow Belt (Yellow Belt) Targeted at key company executives, who will not be directly involved in the projects, but need a basic understanding of Six Sigma.

White Belt (White Belt) They're trained on the fundamentals of Six Sigma. These trainings address the use of the basic tools that apply to the various phases of the methodology, allowing them to have an understanding of the entire process and assist the Green Belts and the Black Belts in implementing their projects.

Source: Adapted from Six Sigma Institute (2016).

The Six Sigma Institute (2016) also states that the Six Sigma methodology incorporates five critical processes (known as Define, Measure, Analyze, Improve, and Control - Define, Measure, Analyze, Improve, and Control) as one of the applicable methods for process improvement.

Define: Definition of the project scope. All processes that can be improved are evaluated and those that represent the greatest threat in relation to defects and faults are selected, and they must be treated within the specifications proposed in the methodology.

Measure: Information is collected and a baseline is defined to depict the current performance of the process. A mapping of the process to be analyzed is done. Metrics are established to help monitor the process. An analysis of the inputs and outputs of the process and its sub-processes, if any, is also performed.

Analyze: In this phase, the causes of each problem encountered are defined, analyzing the process to identify ways to eliminate them. The data is categorized and analyzed according to its trends.

Improve: At this stage solutions are proposed for each problem encountered. With the help of project management tools, the proposed approaches can be implemented, as well as statistical evaluations can identify key areas to focus efforts on process improvement.

Control: With the implementation of identified improvements, the process is brought into a control situation. Control parameters are determined and process stability is monitored.

In summary, these cases are presented in Table 2.
2.2 PROJECT MANAGEMENT

Berssaneti (2012) explains that a project is a set of temporary, group activities aimed at producing a single product, service or outcome. A project is temporary in the sense that it has a definite beginning and end in time, and therefore a defined scope and resources.

The MIP (2013) defines a project as unique in that it is not a routine operation but a specific set of operations designed to achieve a particular objective. Thus, a project team includes people who usually don't work together - sometimes coming from different organizations and multiple geographies.

The development of software for an improved business process (Berssaneti, 2012), the construction of a building or a bridge (Santos, 2008), the relief effort after a natural disaster, the expansion of sales in a new geographic market (Moraes, 2013) - all are projects and must be managed in a specialized way to present the necessary results, learning and integration for organizations within the time and budget foreseen.

Therefore, according to Hors (2012), Project Management is the application of knowledge, skills and techniques for the execution of projects effectively and effectively. It is a strategic competence for organizations, allowing them to link project results with business objectives - and thus better compete in their markets. It was initially practiced informally but began to emerge as a distinct profession in the mid-20th century.

2.3 PMBOK

The Project Management Institute (PMI) is an organization based in the United States that brings together project management professionals in several
countries, who meet at congresses, seminars and several world-wide recognition studies (PMI, 2013).

The PMI brings together in a publication called PMBOK (*Project Management Body of Knowledge*) a set of knowledge needed to manage a Project and makes constant improvements to update this publication. The latest version of this publication is in its 5th Edition.

According to the PMBOK (PMI, 2013), the pillars of Project Management are formed by time, costs and quality, to this trinomial are added seven other areas that are integration, scope, human resources, communications, risks, acquisitions and stakeholders, being this set called the Ten Areas of Knowledge that are necessary to manage a project.

### 2.4 SIX SIGMA AND PMBOK

For Simões (2008), evidence of the results in the business world of using both the *Six Sigma* methodology and the PMBOK as a way of implanting a strategy began to become visible after giants from the corporate world began to win their national quality awards, such as Motorola in the USA or Petrobrás in Brazil.

The *Six Sigma Institute* (2016) points out that the *Six Sigma* methodology has its very concrete goal, which is to record less than 3.4 errors per million opportunities to make mistakes in products and services by focusing on reducing variations in organizational processes. Being used as a methodology to speed up strategic deployment and in the form of projects, *Six Sigma* has proved to be very effective bringing significant results to companies such as Xerox, Motorola, GE, Ford and others, but in Brazil this methodology is still seen as a quality methodology.

With the evolution of the concept of quality, organizations have come to understand the *Six Sigma* methodology as a strategic subject that makes it capable of raising its competitive potential, and the *Six Sigma* methodology is one of the most successful methodologies in prioritizing the achievement of financial results through a structured method (Trad, *et al*., 2009).
While the focus of the *Six Sigma* methodology is on business transformation, PMBOK seeks to structure the strategy for a deployment. The benefits of the *Six Sigma* methodology are in ensuring a performance target and reducing variability in business processes, while PMBOK provides constant monitoring of the deployment and its speed (Hors, 2012).

Hors (2012) also mentions that the barriers are very similar, ranging from the need for a project-oriented structure to the search for greater integration with the business. As for the methodology, it is noticeable that while the *Six Sigma* methodology has phases in which deep measurement and analysis is sought with statistical methods, the PMBOK has a better definition and scope statement and with a greater attention to monitoring the phases of the project.

3 METHODOLOGY
3.1 METHODOLOGICAL CHARACTERIZATION

The research methodology adopted in this work was defined as bibliographic, exploratory (case study) and qualitative with the purpose of systematically describing the scenario found, and investigating the possibilities found, seeking to clarify the theoretical concepts presented in the referential. The research approach will be qualitative, addressing the study of the software developer company, using documentary analysis, observing the environment, interacting with the members of the investigated situations, taking notes on the observed behavior, as well as its results, through the monitoring of activities between January 2016 and April 2016. The company Softplan was requested, formal authorization for the use of the company's name, as well as the data presented in this work, which provided authorization for its exploitation, recognizing the importance of this research.

The bibliographic research was based on consultations with bibliographic and theoretical reference sources such as articles, books, theses, dissertations, websites with content on the *Six Sigma* methodology and on the PMBOK guide obtained from various bases of scientific articles such as *Scielo*, Science Direct, ResearchGateInterests.
3.2 COMPANY CHARACTERIZATION

The object of this article's research is the analysis of a case study by Softplan, a software factory located in Santa Catarina, with its sub-headquarters located in São Paulo. The company provides solutions for all Brazilian states, America, Latin America and also in the United States.

Softplan is one of the largest companies in Brazil in the development of management software. Since 1990, the company has acted in such a way as to make public and private management in Brazil more transparent, efficient and agile with the use of modern and innovative technologies. Over these years, Softplan has specialized in the development and deployment of management software for the Justice, Infrastructure and Works, Public Management, Projects Co-financed by International Organizations and Construction Industry (SOFTPLAN, 2017).

The case study focuses on the internal project of the Applications Infrastructure area, located within the main client of Softplan company in São Paulo, which uses the Judicial Automation solutions SAJPG5 (First Degree - PG) and SAJSG5 (Second Degree - SG).

The project aims to review the main processes in the area, and propose improvements in them, using as support the Six Sigma methodology. The Application Infrastructure area is allocated within Softplan's main client for strategic reasons, since its entire scope of activities must be performed within the client environment, providing greater security and agility in the execution of them.

Within the scope of activities in the area are two extremely critical processes, both for the company Softplan and for the customer. These are:

a) SAJPG5 Family Applications Version Update: Consists of PG5, ADM, SGC, PRO, EST, and PSS applications, belonging to the client's pool of Judicial Automation solutions for First-Degree (First Instance) trials.

b) SAJSG5 Family Applications Version Update: Consists of SG5, ADM, PRO, SGC and PSS applications, belonging to the client's pool of judicial automation solutions for Second-Degree (Second-Instance) case trials.
The products delivered to this client consist of client-server software solutions distributed in a pool of servers classified as mentioned below:

a) Application Servers: Virtualized servers, located in Datacenters, responsible for the connection of the application located in the workstations to the database servers;

b) Edge Servers: Physical servers located in the physical locations of the client, serving as a repository for the distribution of update packages;

c) Database Servers: Physical servers, located in Datacenters, where database instances are configured and run.

Applications work by having their objects (executables, libraries, help files, etc.) distributed between application servers and edge servers in predetermined directories to be available for use when connection services are enabled.

The concept of edge servers functions as a central FTP (File Transfer Protocol) server in the physical location of workstations so that when the version is upgraded, stations receive the upgrade quickly, directly from the edge server, within their respective Local Area Network (LAN), without burdening the local infrastructure, such as overloading the data link in transmitting objects to all workstations.

Quantitatively, the customer has 214 application servers for the PG and 38 application servers for the SG, as well as 528 edge servers for the PG and 15 edge servers for the SG, which during the version upgrade process should receive the version objects, and be ready for use as soon as the procedure is completed. There are also 8 database servers, where configuration scripts for parameters and tables are run so that the databases fit each software version.

3.3 PROBLEM CHARACTERIZATION

Being the application of the Six Sigma methodology in the area of application infrastructure based on a project, PMBOK served as a guide for the project to follow the recommended standards as being efficient and effective for its success.
As recommended by the PMBOK (PMI, 2013), the opening term of the project was used, where the following guidelines were established:

As to the project objective: Implement the *Six Sigma* methodology to the main processes of the Application Infrastructure industry, regarding software version update.

As to the scope of the project: Implement the *Six Sigma* methodology to key processes in the Application Infrastructure industry, aiming to standardize them, eliminate failures, reduce costs and optimize their execution time.

Assumptions:

a) The two main existing processes in the Application Infrastructure sector, which were drawn up previously, will be analyzed.

b) Possible improvements that previously analyzed processes might receive will be evaluated and documented.

c) Validation metrics of execution success, as well as time and cost for each process analyzed, will be established, improving existing ones and creating new indicators when needed.

Restrictions:

a) All analysts involved must have at least the *Six Sigma White Belt* Certification to have basic knowledge of the methodology.

b) The activities of analysis and documentation will be done in parallel with the daily activities of the area, not hindering the progress of these activities.

The following guidelines have been established for the implementation of the project:

As for the baseline of the project scope: Use the *Six Sigma* methodology for key processes in the Application Infrastructure industry to standardize them, eliminate failures, reduce costs and reduce their execution time.

The Analytical Project Structure (WBS, figure 1), of the said project, aimed at greater visibility of the tasks to be carried out, based on concepts contemplated in the PMBOK 5th Edition, 2013.
The WBS Dictionary (figure 2) was also prepared to indicate the acceptance criteria for each WBS shipment.

**Figure 2 – WBS Dictionary Clipping.**

<table>
<thead>
<tr>
<th>WBS Code</th>
<th>Delivery</th>
<th>Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Analyze Existing Processes</td>
<td>The main processes of the Application Infrastructure area will be analyzed to identify existing failures.</td>
</tr>
<tr>
<td>1.1</td>
<td>Analisar Processo de Liberação de Versão SAJPG5</td>
<td>It will be analyzed the process from the availability of version packages in corporate FTP, release in homologation until the final release in production.</td>
</tr>
<tr>
<td>2</td>
<td>Analyze Improved Processes</td>
<td>Analysis of the proposals for improvements in each process under analysis.</td>
</tr>
<tr>
<td>2.1</td>
<td>Define Improved Processes</td>
<td>Definition of the flow of the processes already with the improvements implemented.</td>
</tr>
<tr>
<td>3</td>
<td>Define new KPIs</td>
<td>Definition of KPIs that contemplate the maintenance of the execution of the analyzed processes.</td>
</tr>
<tr>
<td>3.1</td>
<td>Define Assertiveness Indicator</td>
<td>Definition of assertiveness KPIs for the analyzed processes.</td>
</tr>
<tr>
<td>3.2</td>
<td>Define Time Indicator</td>
<td>Definition of runtime KPIs for the analyzed activities.</td>
</tr>
<tr>
<td>3.3</td>
<td>Define Cost Indicator</td>
<td>Definition of execution cost KPIs for the analyzed activities.</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Details</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>3.4</td>
<td>Define Resource Indicator</td>
<td>Definition of KPIs of resources allocated to the analyzed activities.</td>
</tr>
<tr>
<td>4</td>
<td>Tools Analysis</td>
<td>Analyze the current and proposed tools for the execution of the analyzed processes.</td>
</tr>
<tr>
<td>4.1</td>
<td>Analysis of Tools in Use</td>
<td>Analysis of the tools in use for the execution of the processes under analysis.</td>
</tr>
<tr>
<td>4.2</td>
<td>Analysis of Proposed Tools</td>
<td>Analysis of the tools proposed as an improvement for the execution of the processes under analysis.</td>
</tr>
<tr>
<td>5</td>
<td>Training</td>
<td>Training of the analysts involved in all the technical context of the project.</td>
</tr>
<tr>
<td>5.1</td>
<td>Six Sigma Certifications</td>
<td>Incentive for all analysts involved in the project to achieve at least the basic certifications of Six Sigma (White Belt), aiming at contextualization with the methodology being implemented.</td>
</tr>
<tr>
<td>5.2</td>
<td>Transfer of Six Sigma Tools</td>
<td>Forwarding of application information of the DMAIC method.</td>
</tr>
<tr>
<td>5.3</td>
<td>Tool Forwarding</td>
<td>Passing on information for the application of the DMADV method.</td>
</tr>
<tr>
<td>5.4</td>
<td>Transfer of New Internal Tools</td>
<td>Passing on information on the use of the tools proposed as improvement to all team members, aiming at equalization of knowledge.</td>
</tr>
<tr>
<td>6</td>
<td>Analysis of New Processes</td>
<td>Analysis of new processes inserted in the routines of the Application Infrastructure team.</td>
</tr>
<tr>
<td>6.1</td>
<td>Identification</td>
<td>Identification of all new processes inserted in the routines of the Application Infrastructure team.</td>
</tr>
<tr>
<td>6.2</td>
<td>Design</td>
<td>Design of all new processes inserted in the routines of the Application Infrastructure team.</td>
</tr>
</tbody>
</table>


The Responsibility Matrix (RACI Matrix, figure 3), was also developed by the project's execution team, aiming to present all Stakeholders involved, how to define their responsibilities during the project.
Descriptions of run-time estimates can be seen in figure 4. A schedule with defined milestones was not stipulated, because the project was run in competition with the area’s standard activities, creating only an estimate of the time for execution of the activities.

<table>
<thead>
<tr>
<th>Activities</th>
<th>Description</th>
<th>Resources</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Analyze Existing Processes</td>
<td>Analyze mapped process flow in Bizagi to identify fault points</td>
<td>Infrastructure Analyst</td>
<td>40 hours</td>
</tr>
<tr>
<td>1.1 Analyze Version Release Process SAJPG5</td>
<td>Analyze mapped process flow in Bizagi to identify fault points, categorizing and relating them all</td>
<td>Infrastructure Analyst</td>
<td>40 hours</td>
</tr>
<tr>
<td>1.2 Analyze Version Release Process SAJSG5</td>
<td>Analyze mapped process flow in Bizagi to identify fault points, categorizing and relating them all</td>
<td>Infrastructure Analyst</td>
<td>40 hours</td>
</tr>
<tr>
<td>2. Analyze Improved Processes</td>
<td>Analyze proposals for improvement aimed at the process</td>
<td>Infrastructure Analyst</td>
<td>3 weeks</td>
</tr>
<tr>
<td>2.1 Improved Processes</td>
<td>Definition of improvements to be implemented in the process</td>
<td>Infrastructure Analyst</td>
<td>8 hours</td>
</tr>
<tr>
<td>2.2 Design Improved Processes</td>
<td>Improved process design in Bizagi tool</td>
<td>Infrastructure Analyst</td>
<td>24 hours</td>
</tr>
</tbody>
</table>

With regard to the budget, since it is an internal project of the Systems Infrastructure team, there was no need for a definition of the budget.
Measuring the Progress of the Project was carried out through weekly meetings with those involved. Completed and ongoing activities were reported and evaluated, with an assessment of the execution time, adherence to the original proposal, and what results were achieved.

Like the WBS, an Risk Analysis Structure (RAS, figure 5) was also developed, so that the team and the Stakeholders could have a greater vision of the possible risks that could affect the project, as demonstrated below.

![Risk Analysis Structure (RAS)](source: SOFTPLAN (2017))

### 3.4 PROPOSAL FOR IMPROVEMENT

The processes evaluated by the DMAIC method were: "Release Version SAJPG5" and "Release Version SAJSG5". Although they are distinct processes, the execution mechanics of both are identical, allowing the team to analyze both processes together. According to DMAIC, the points of failure/opportunities for improvement of the processes in question were identified:

a) DEFINES:

Below are the failure points/improvement opportunities found:
Full stop of SAJPG5/SG5 services and execution conferencing; cleanup of cache directories and execution conferencing; distribution of server objects and download checking; distribution of client objects to Edge Servers via Batchs and download checking; distribution of client objects to edge servers via Transfer Console (object distribution tool) and download checking, distribution of client objects to directories and download checking, distribution of secondary client objects (ADM, PRO, SGC, EST, PSS) and scan downloading; executing of scripts using the CAPRONI application (Script Execution Tool), and applying proper command tags to each execution type; configuring spcfg.ini files from the PSS application and executing conferencing; initiating SAJPG5/SG5 services and executing conferencing.

Until now, before this analysis, all checks on the implementation of these activities were manual, which entailed a long time of verification, liable to inattention in the verification.

The entire process after its execution 99% of the time had 100% assertiveness in its execution, but there were occasional cases of failures due to the failure of the manual procedure, generating impact on the operation.

Regarding the cache directory cleanup, we had an approximate one (1) hour delay in performing this activity. We also note that in addition to the operational part, pointed out above, there are administrative factors that have been assessed, such as the execution time and the cost of performing these tasks.

Regarding the time/cost of performing these tasks we have the following aspects to analyze: as most of these activities are performed outside of business hours by customer's need, as a result overtime is generated. Already to these tasks are added meal and commuting costs for each analyst involved in these activities.

b) FOR MENSURE:

The following samples were collected from January 2016 until April 2016 (figure 6). According to the information presented below, we found that in the version update of day 01/02/2016, there was a failure in the execution of the
process, in which 3 application servers failed due to the non-distribution of the
client package SAJPG5 PSS, detected by the Customer Monitoring Team, already in business hours.
**Figure 6 – Clipping from the Metric Worksheet.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Release</th>
<th>Objects</th>
<th>Application Servers</th>
<th>Edge Servers</th>
<th>Application Servers Failed During Upgrade</th>
<th>Edge Servers Failed During Upgrade</th>
<th>Post-Update Failed Application Servers</th>
<th>Server Hit Rate</th>
<th>Post-Upgrade Failed Edge Servers</th>
<th>Edge Server Hit Rate</th>
<th>Analysts Involved</th>
<th>Runtime Approx.</th>
</tr>
</thead>
<tbody>
<tr>
<td>07/01/16</td>
<td>1.8.7-7_C</td>
<td>5</td>
<td>191</td>
<td>521</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100%</td>
<td>0</td>
<td>100%</td>
<td>1</td>
<td>2 hours and 30 minutes</td>
</tr>
<tr>
<td>12/01/16</td>
<td>1.8.7-11</td>
<td>20</td>
<td>191</td>
<td>521</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>100%</td>
<td>0</td>
<td>100%</td>
<td>2</td>
<td>5 hours</td>
</tr>
<tr>
<td>13/01/16</td>
<td>1.8.7-11_A</td>
<td>5</td>
<td>191</td>
<td>521</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>100%</td>
<td>0</td>
<td>100%</td>
<td>2</td>
<td>2 hours</td>
</tr>
<tr>
<td>19/01/16</td>
<td>1.8.7-11_B</td>
<td>5</td>
<td>191</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100%</td>
<td>0</td>
<td>100%</td>
<td>1</td>
<td>2 hours</td>
</tr>
<tr>
<td>01/02/16</td>
<td>1.8.7-12</td>
<td>19</td>
<td>191</td>
<td>521</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>98%</td>
<td>0</td>
<td>100%</td>
<td>2</td>
<td>2 hours and 30 minutes</td>
</tr>
<tr>
<td>02/02/16</td>
<td>1.8.7-12_A (SERVER)</td>
<td>3</td>
<td>191</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100%</td>
<td>0</td>
<td>100%</td>
<td>2</td>
<td>1 hour and 15 minutes</td>
</tr>
<tr>
<td>17/02/16</td>
<td>1.8.7-14</td>
<td>19</td>
<td>191</td>
<td>521</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>100%</td>
<td>0</td>
<td>100%</td>
<td>3</td>
<td>4 hours</td>
</tr>
<tr>
<td>02/03/16</td>
<td>1.8.7-17</td>
<td>19</td>
<td>191</td>
<td>521</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>100%</td>
<td>0</td>
<td>100%</td>
<td>2</td>
<td>3 hours and 50 minutes</td>
</tr>
</tbody>
</table>

c) ANALYSIS:

This stage of the methodology addressed the forms of analysis indicated by the tool:

Root Cause Analysis: As a premise of failure analysis is the inefficiency of manual checks of process execution, in which by an oversight of the human factor, a transfer failure can go unnoticed. The running time of scripts was also evaluated as notorious, which depending on the number of scripts might require a high execution time.

Process Analysis: It was verified that the process mechanics is slow and subject to failures due to manual object transfer conference.

Data Analysis: The collected data shows the aspects related to the execution steps, time and cost of the activities. Since the process inputs are always the same, the outputs should also be the same, but it is verified that there was a time when the process failed, due to failure in the transfer of the objects conference, because it is manual.

Resource Analysis: The resources used for the activities are components of the Application Infrastructure team, which are participants in the project.

Communication Analysis: Activities are always communicated through emails directed to each category of stakeholder component team: Softplan São Paulo teams, Softplan Santa Catarina teams, Customer Network Infrastructure teams and customer monitoring teams.

d) IMPROVE:

In order to obtain improvements to the problems presented, it was concluded that a gain could be achieved if a technological solution were implemented.

To inhibit the human factor in manual checks of object distributions, team members studied the development of a set of applications that would automate object distribution activities during a version upgrade. The suite of applications called SSUP (System Support Update), was developed in Powershell, using resources from the Windows operating system itself, discarding the need for free or paid third-party development tools.
In relation to script execution using the CAPRONI tool, developed by Softplan's development team, the way of execution was improved by inserting tags to the main command to optimize the execution time: it was observed that always when a script presented error and, after its correction, the need to run the CAPRONI application again, it redid the initial verification, before the execution of the package scripts. Depending on the number of scripts and the content of the scripts, the re-check took an unnecessary amount of time and had already been run before. Thus the application of the tag mentioned below allowed the CAPRONI application, when run for the second time, after some script correction, to start directly at the execution of the missing scripts. E.g. capronica3 -is -ns, where the spelling includes the name of the application to be executed, as well as the -is TAGS (Scripts already run) and -ns TAGS (ignore simulation and run directly).

In relation to the execution time of activities (figure 7), there was a mishap that to ensure the transfer of client objects to edge servers, we used two forms of distribution: via batches and via Transfer Console, which were performed at different times aiming at the complete assertiveness of the activity, since one activity conflicted with the other if performed simultaneously. This resulted in twice the running time for this activity, which was set at one hour each.

The SSUP tool Implementation started to do not only the transfer of the client objects in an automated way to the edge servers, but also allowed through a verification tool, called Target, also of internal development of the team, to point out if there was a failure in the transfer to any edge and application server, object corruption due to network degradation, as well as validating the transfer through the time and date of compilation/creation of the object.

With the implementation of the SSUP tool, a feature to clear System Cache folders was introduced that optimized the time from approximately 1 hour, to 5 minutes on average for both small and large updates.

On average, a small SAJPG5 client/server upgrade lasted on average 3 Hours. After the SAAT Tool Implementation, the same update category ran for an
average of 1 hour. For major release upgrades, the runtime was up to 16 hours, and ran for 5 hours.

Consequently to the problems pointed out above we have the reduction of the running time of the activity, which has made possible the decrease of generation of overtime, as demonstrated in figure 7.

Figure 7 – Data collected regarding the execution of activities.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Before SAAT Deployment</th>
<th>After SAAT Deployment</th>
<th>Improvement Achieved at Runtime</th>
<th>Improvement Achieved in Assertiveness</th>
<th>Improvement Achieved in Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium Runtime Update Client/Server</td>
<td>3 Hours</td>
<td>1 Hour</td>
<td>66,67%</td>
<td>100%</td>
<td>66,67%</td>
</tr>
<tr>
<td>(Correction)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium Client/Server Update Runtime</td>
<td>16 Hours</td>
<td>5 Hours</td>
<td>62,50%</td>
<td>100%</td>
<td>62,50%</td>
</tr>
<tr>
<td>(Deployment)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cache Directory Cleanup Time</td>
<td>1 Hour</td>
<td>5 Minutes</td>
<td>91,67%</td>
<td>100%</td>
<td>91,67%</td>
</tr>
</tbody>
</table>


e) **CONTROL:**

All previously discussed improvement processes are documented and metrified by collecting data after each process is performed.

After the implementation of the scripting tools and practices, all data is logged so that continuous monitoring is done to measure the efficiency of the processes addressed.

Finalizing the activities related to the project, the processes were redesigned in a single flow (figure 8), which started to approach the two processes in a lean and objective manner. Previously, the processes were dealt with in different flows, but the application of the technological solution made it possible to standardize the processes.
4 ANALYSIS OF RESULTS

The Six Sigma Methodology presents methods to be used in the identification and analysis of scenarios that can affect the processes studied, such as DMAIC. In the case of the processes analyzed by Softplan in relation to Software Release Distribution, we note that the process was already at a very high degree of maturity, but there was a need to eliminate all possibility of error that could occur, and also to reduce the times and costs.

The analysis of the processes made it possible to conclude that a technological solution would be an alternative to ensure the assertiveness of the activities, besides that it would make possible solutions for verifying the most efficient and effective activities.

With the implementation of the SSUP tool, developed by the team responsible for the process, the results were immediately achieved by eliminating to 0 (zero) the errors that occurred and optimizing the time and cost of the activities.
We can then conclude that the Six Sigma methodology was important in directing actions and assisting in the decisions of the project team, allowing the application of quick and effective solutions to problems encountered previously.

5 CONCLUSION

This study provided validation of the application of the jointly applied Six Sigma quality methodology and PMBOK guide, providing results to achieve maximum quality of the release management process. The adherence of the tools applied in a clear way can be observed, respecting the context of the reality of the assessed scenario.

The field exploration of the joint application of the Six Sigma methodology and the PMBOK guide in the release management process in software development companies was one of the main motivators for the elaboration of this study.

It was verified that the knowledge of the collaborators who worked directly in the execution of the project was fundamental for the correct interpretation and application of the method presented in the Six Sigma methodology and in the PMBOK guide in the release management process.

The distribution of responsibilities in a coordinated manner meant that activities and their tasks could be performed in an organized manner, being reviewed in real time, before finalizing the process and then releasing it into production. The application of the DMAIC method using the practices suggested in the PMBOK guide has made it possible to implement the project clearly and quickly, making it easy for all parties involved, both the client and Softplan company, to understand.

With the results obtained in this research it is possible to offer academic contributions to the study and application of methodologies and best practice guides together, and how much they can offer in obtaining measurable results to companies, since the tools offered can be applied to other areas of the company, whether for the management of processes, people or technologies.
As a suggestion for future work it will be interesting to promote validations of continuous improvement on the results achieved, since the area of Information Technology is constantly changing and evolving. It can be said that a result obtained today may not be satisfactory in the near future, which will require further evaluation and study, and even the application of new techniques or practices proposed by other methodologies or best practice guides. Specifically, the study presented will be proposed to apply a continuous improvement evaluation to look for the evolution of the efficiency and effectiveness of the release management process.

ACKNOWLEDGMENT

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