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IMPLANTATION AND CERTIFICATION OF A QUALITY MANAGEMENT SYSTEM IN ROLLING STOCK MAINTENANCE OF METRÔ-DF

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We dedicate this Project

To all professionals who develop activities in Rail and Metro Rail Systems and who constantly seek to produce the best results.

To employees and public servants, who work hard to serve society, with the quality due in the services provided.

ACKNOWLEDGEMENT

"Quality is never an accident. It is always the result of intelligent effort.

John Ruskin"

"Quality starts with intention, which is set by management"

Dr. W. Edwards Deming

ABSTRACT

An important factor associated with business success in several sectors, quality management has become an outstanding tool for obtaining results consistent with stakeholder expectations. As a relatively new company in its sector, METRÔ-DF consolidates itself as one of the main transport agents in the capital Brasília, always seeking to innovate in its business. Therefore, the present work presents an analysis of the current situation aimed at the implementation of quality management mechanisms in which a proposal aimed at obtaining the accreditation accredited by the ISO 9001 standard will bring internal and external benefits. An evaluation of this implementation was carried out in the maintenance of the rolling stock, in which implementation costs and direct benefits of it were raised, translated into a reduction in the contractual maintenance costs. The project proved to be viable as it presented a Benefit / Cost of 1.33 for a 3-year horizon for certification ranging up to 1.8 in continuity of certification, the same was observed, respectively in Payback varying 4.5 to 3.2 years according to the project term. It is observed by studying the case of the rolling stock the feasibility of implementing the certification for the other areas of maintenance.

Keywords: ISO9001: 2015, Quality Management, Maintenance, Rolling Stock, Certification.

ABSTRACT IN PORTUGUESE

Importante fator associado ao sucesso empresarial em diversos setores, a gestão da qualidade tornou-se uma ferramenta de destaque para a obtenção de resultados consistentes às expectativas dos stakeholders. Como uma empresa relativamente nova no seu setor, o Metrô-DF se consolida como um dos principais agentes de transporte da capital Brasília, sempre buscando inovar em seus negócios. Assim sendo, o presente trabalho apresenta uma análise da situação atual voltada à implementação de mecanismos de gestão da qualidade em que uma proposta visando a obtenção da certificação acreditada na norma ISO 9001 trará benéficos internos e externos. Foi feita uma avaliação de tal implementação na manutenção do material rodante, em que se levantaram custos de implantação e benefícios diretos disso, traduzidos em uma redução dos custos contratuais da manutenção. O projeto mostrou-se viável à medida em que apresentou um Benefício/Custo da ordem de 1,33 para um horizonte de 3 anos para a certificação variando até 1,8 em uma continuidade da certificação, o mesmo se observou, respectivamente no Payback variando de 4,5 a 3,2 anos de acordo com o prazo do projeto. Observa-se pelo estudo do caso do material rodante a viabilidade da implementação da certificação para as demais áreas da manutenção.

Palavras Chave: ISO9001:2015, Gestão da Qualidade, Manutenção, Material Rodante, Certificação.

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LIST OF ABBREVIATIONS

ABNT	Associação Brasileira de Normas Técnicas
CAO	Administrative and Operational Complex
CHESF	Companhia Hidrelétrica do São Francisco
CMMS	Computerized Maintenance Management System
CBA	Cost Benefit Analysis
CPTM	Companhia Paulista de Trens Metropolitanos
DOM	Operation and Maintenance Directorate
EPIA	Estrada Parque Indústria e Abastecimento
Inmetro	Instituto Nacional de Metrologia, Qualidade e Tecnologia
IPCA	Índice Nacional de Preços ao Consumidor Amplo
ISA Associations	International Federation of the National Standardizing
ISO	International Organization for Standardization
METRÔ-DF	Companhia do Metropolitano do Distrito Federal
METRÔ-SP	Companhia do Metropolitano de São Paulo
NPV	Net Present Value
PDCA	Plan, Do, Check and Action
QMS	Quality Management System
SEMOB	State Secretariat Mobility
SMT	Maintenance Superintendence
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TQC	Total Quality Control

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1. INTRODUCTION

This work will explore the conditions and factors existents in maintenance of Rolling Stock of metro rail company of Brasilia, capital of Brazil. Through a critical analysis it will propose the basic steps and procedures in which the company can achieve a goal to have an implemented Quality Management System over its activities.

The major contribution of this work is to reveal the opportunities and advantages of such implementation, exploiting the benefits for the first cycle of certification process.

The work starts presenting the research results, explaining the motivation, the metrics and the objective of the proposal. This section will state the actual scenario of the company.

2. RESEARCH RESULTS

2.1. Initial concept: About Metrô-DF

The Company, named Companhia do Metropolitano do Distrito Federal, populary known as METRÔ-DF, is a public company, ruled by Private Law, in the form of a stock company, was established by Article 1 of the Federal District's law No. 513, of July 28, 1993, and is, currently, submitted to the State Secretariat Mobility - SEMOB, governed by Federal Law No. 6.404/ 1976, and integrates the Indirect Administration of the Government of the Federal District. Its competences are to plan, design, build, operate and maintain the public transport system on rails in the Federal District.

The METRÔ-DF project consists of 29 stations, where 27 of them are currently in operation. Its fleet includes 32 trains, with 24 trains running during peak hours, carrying, on average, 160 thousand passengers per day.

The entire commercial route is 42.38 km long and connects the administrative region of Brasília to the administrative regions of Ceilândia and Samambaia, passing through Asa Sul, Setor Policial Sul, Estrada Parque Indústria e Abastecimento (EPIA), Guará, Park Way, Águas Claras and Taguatinga, as can be seen in the Figure 1.
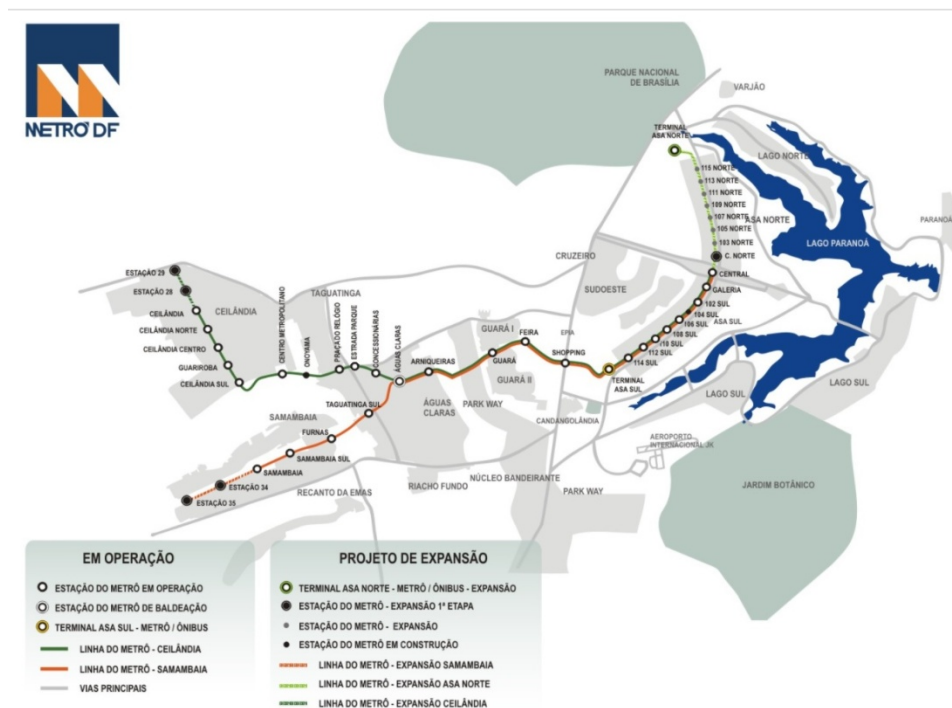
Figure 1 – Metrô-DF Line Map

Currently, the Company has approximately 1,268 employees, allocated to 5 boards, whose technical staff has significant knowledge of the subway system. About half of the entire workforce has 20 or more years of service in the company.

2.2. The Maintenance Services in Metrô-DF

At METRÔ-DF, the organic unit responsible for the management, inspection and promotion of maintenance activities is the Maintenance Superintendence - SMT, submitted to the Operation and Maintenance Directorate - DOM.

This superintendence has 92 employees, distributed in the three maintenance managements, namely: Maintenance Management of Fixed Systems and Rolling Stock, Maintenance Management of Permanent Way and Buildings, and Management of Workshops, as can be seen in organization chart shown in Figure 2.
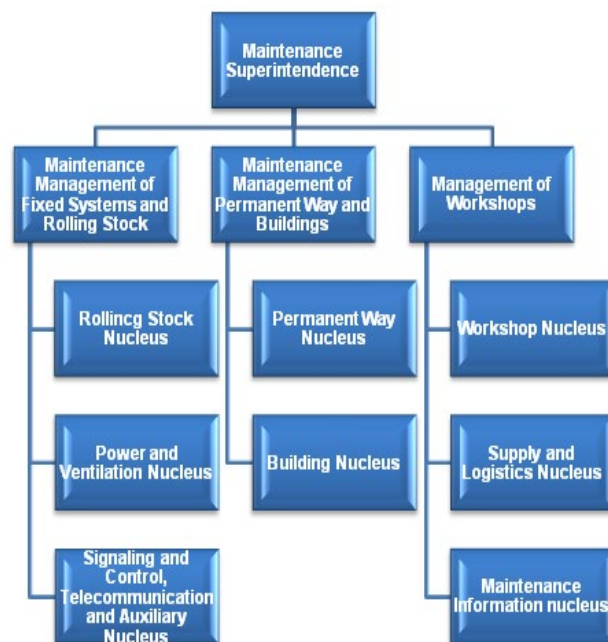
Figure 2 – Organizational Chart of Maintenance Superintendence

Maintenance activities (preventive, predictive and corrective) of METRÔ-DF trains are carried out at Pátio Águas Claras (Aguas Claras Yard), in the Maintenance Complex, located next to the Administrative and Operational Complex (CAO), where there are also located: the maintenance warehouse, the electronics laboratory, the battery maintenance room, the painting room, the electromechanical and pneumatic workshops, among others.

There is also the mobilization of technical teams in Pátio Águas Claras, on duty 24 hours a day, seven days a week, to attend in case of any problem in the trains or in any other system (Energy, Signaling and Control, Telecommunications, Ventilation, Permanent Way, Buildings, Escalators and Elevators, Air Conditioning, among others), totaling 437 employees of outsourced companies under the supervision of METRÔ-DF´s Management and Inspection crew.

The figures 3 and 4 show the headquarter and maintenance yard of the METRÔ-DF.

Figure 3 – Headquarter and maintenance yard of Metrô-DF

Figure 4 – Maintenance yard of Metrô-DF

2.3. Problems faced in maintenance activities

METRÔ-DF maintenance teams work are allocated in different Systems and work fronts, with a large volume of activities and information to be processed. As an example, in 2019, 63,834 work orders were executed and, from January 2020 until September 2020, 44,875 work orders were executed, among corrective and predictive maintenance activities.

These maintenance services are performed based on maintenance procedures developed by the METRÔ-DF technical teams, in which are included the following information: the materials to be used, the labor and the necessary qualifications, the tools and instruments to be used, the frequency of performance of services, how to perform the activity, among others. Currently, 485 procedures are in place and there are others under development by the company's maintenance and engineering team.

But, despite all efforts, so far, the maintenance activities of METRÔ-DF do not have any quality certification regarding its internal processes, whether they are: inspection of activities, execution of activities, training, elaboration of maintenance procedures, acquisition of materials and services, among others.

There is no standardization in the performance of activities, nor is the degree of efficiency and quality of the services provided correctly measured. There is only the verification of maintenance indicators for payment purposes to those contracted for their services provided. The indicators are:

- Average release time of activities performed on the Systems;

- Average Mileage between Train Failures;

- Train Availability;

- Systems availability;

- Compliance with scheduled preventive maintenance;

- Maintenance Rework Index;

- Deadline for Executing Service Orders in the Systems;

- Workshop Repair Deadline.

However, it is observed that some companies that provide maintenance services to METRÔ-DF, already have the certification for the promotion of quality in maintenance, ISO 9001, which is a Quality Management System - QMS, in order to guarantee the optimization of processes, greater agility in the development of products and services, among others, in order to satisfy customers (passengers) and achieve sustained success.

2.4. Understanding the context

As the number of companies that applies Quality Management Systems over its processes just increased since the 1980's, several success cases, papers and knowledge database about the subject is available nowadays.

To keep this project in touch with the reality of the transportation industry where Metro-DF is inserted and Brazil's regulatory peculiarities, the research was based upon the cases, the routines and the performance of national companies under the developing of the ISO 9001 at their business.

The first company approach research for a benchmark was Metro de São Paulo. Since the company is the oldest and the largest metro operator of Brazil, operating in the largest city of the country, São Paulo, their experience must be taken as a suitable guide for the implementation of QMS in Brasilia, exposing some common shortcuts and some challenges inherent to projects of the kind.

The experience in Metro of Sao Paulo started in early 1990s with the adoption of tools based on Japanese's TQC – Total Quality Control. That approach ran over four initial missions with a scope limited to Maintenance Department:

- Review of Maintenance Procedures,

- Standardization,

- Organization and Cleaning and,

- Critical analysis meetings.

Firsts audits were made by company's own staff and prepare the scenario for the certification.

The pos-certification scenario evolved to the creation of a Quality Department in the hierarchical structure of the company, initially composed by the first internal auditors. Nowadays, this Management is also certified by ISO and OHSAS, according to information provided by METRO FO SAO PAULO´s staff.

Benchmarked with a reference operator, the research went toward the main contractor of maintenance services in Metro-DF, MPE ENGENHARIA, certified by ISO in 2018.

MPE Engenharia is a company that owns five contracts with Metro-DF:

- Maintenance of Rolling Stock,

- Maintenance of Signaling, Control and Telecommunications systems,

- Maintenance of Track,

- Maintenance of Electrical Supply system and,

- Maintenance of Buildings.

As established by the head office, based in Rio de Janeiro, the branch of the company responsible for the METRO-DF contracts started its certification process in 2017.

As an initial step, an initiative based on 5S system started in all departments of the contractor, and consisted of a team competition, with symbolic prizes. This competition improved the engagement of the workers for the next step: document and monitoring all the internal processes on METRO-DF maintenance system?.

Based on all the requirements of the ISO 9001 standard and the previous experience from the head office and other contracts, the branch achieve the certification in seven months.

Nowadays, external audits take places each year, evaluating both the maintenance of quality level and the implementation of improvements suggested by the last audit.

Another company in service of METRO-DF is Engecompany, which is a supplier and maintainer of the Engeman software, a CMMS (Computerized

Maintenance Management System) used as a tool that automates the routine of maintenance activities. It records information about maintenance activities and provides an environment where it can be managed. The current volume of information from the processes is too large to be maintained only in printed papers or simple spreadsheets. In addition, it allows the programming and control of the activities carried out, in addition to producing different reports of: performance of maintenance indicators; activities by system; costs; warehouse stocks; productivity; among others.

Considering that the analysis has achieved two cases linked to METRO-DF: one from a Brazilian operator and other from a contractor stablished at the METRO-DF´s maintenance plant, the missing part for develop the pathway for the implementation in the company was the case study of a recent government owned company certification.

Since 2016, law in Brazil regulates a specific contracting regime for public companies. Relying upon the common requirements and documentation involved in this kind of process, a recent contract initiated by Companhia Hidrelétrica do São Francisco (CHESF), through a public bidding, was used as a model for this project.

By the end, the group also researched the internal environment of METRO-DF, in order to find shortcuts that can be assumed on already running initiatives.

As an example of this, a Special Task Group was recruited in 2019 to update and standardize the maintenance procedures documentation aiming the segregation of costs in preventive maintenance. Although the initial goal was not oriented to ISO certification, all the results can be assumed as part of the Quality Management System implementation.

All the theoretical background was detailed in a specific chapter of this work, that also includes the analysis of the ISO 9001 standard in a way that the requirements and procedures meet the reality and scenario where Metro-DF is inserted.

2.5. Objective of the work

Previous sections of this chapter described the motivation and methodology adopted in research. Thus, the challenge and innovation proposed here for the company is to obtain from this results a suitable schedule, a realistic scope, an implementation plan and a contracting model that allows the creation of a Quality Management System and to be certified for the first time.

3. HYPOTHESIS

Under the results obtained through research, several hypotheses were proposed to be tested in the development of this work. Since the implementation of a Quality System demands the schedule, the scope and the costs of the project to match the organization reality, not all the steps and achievements obtained in case studies will be suitable to METRO-DF.

Firsts hypotheses tested in this work refers to scope:

- If the certification process aims one system individually, both time and costs of the project will be more attractive to decision makers of the company.

- The implantation of a Quality System aimed first to Rolling Stock system will be more sensible to stakeholders.

The idea of individualizing the certification was considered in order to reduce the complexity of the process of standardization and measurement of the results, since a more embracing scope can lose the effectiveness by deal with a singular approach to systems that holds different challenges.

If confirmed the previous argument, one unavoidable question emerges: What system can provide a more impressive result in terms of quality to the main board, customers, and government?

All service provided by METRO-DF, in the end, results in transporting people. Trains are not only the most valued asset, but also the equipment where users spent more time interfacing inside the metro rail system.

By developing the arguments to sustain or refuse these statements, is possible to validate the last hypotheses:

- Defining scope, the costs involved will improve business opportunities.

Once METR-DF is inserted as part of the public budget of Federal District, it must clear to the society that all the costs estimated for a quality system implementation would result in improvements whether operational, financial or in business opportunities.

4. GENERATE IDEAS

Based on research results and prospects, is possible to classify METRO-DF as an incipient company regarding to Quality Management assumptions?

Even with lot of process documented, approved, and kept in track with updates, the quality in execution of internal activities are still dependent of the evaluation of the executor itself.

The ideas arising from this research and from the problem exposed was split the objectives into four fields of action:

- Determination of company's areas that are more likely to obtain the certification and to add value to its tasks in the after-certification period;

- Trace strategies aimed to continue the development of quality of the area selected;

- Ensure budget predictability to sustain the continuous process of maturing a Quality Management System implementation;

Trace strategies aimed to gather the workforce around the goal of set a new level of quality of the company.

4.1. Delimitation of the scope

As shown in previous sections of this work, the Rolling Stock maintenance is a very suitable area to implement a Quality Certification when considered the positive impacts.

First of them are the visibility and the user perception, once this is the system with more interface with general public.

Also, the benefits will cover the most valuable assets in operational plant of the company.

Other important remark for this system is that both contractors and the software used to manage maintenance workorder and materials are already developed under the pillars of ISO standards.

The ideas for improve quality of maintenance of trains and embedded systems are:

- The utilization of latest updates on maintenance procedures made under a Special Task Group created for detailing costs in maintenance.

- The customization of the software and database of maintenance to keep track of quality indicators.

- To develop a formal quality strategy regarding to workorders, materials, tools and services in Rolling Stock Nucleus.

It was also perceived, under the development of this work, that the culture already existent for this team brings both strengths and weaknesses to be developed, maintained or counter-measured to achieve the goals. A SWOT analysis must be performed to raise these indicators positively.

4.2. Strategies for future outcomes of Quality Management implementation

As a public company, the budget of Metro-DF must attend to the General Budget of Federal District, stablished by a local law at the very beginning of each year. Also, multiyear impacts must be eligible to fit the pluriannual plan for the state.

The idea brought to financial concerns about certification and implantation is to get together information and experience from other companies included in the same legal situation. This can be done by a market survey.

The purpose of this work is to give an order of magnitude of how much capital must be invested before and after the certification.

The concern about the future costs matches with the purpose of predictability of the public budget, avoiding costs that seems fair enough on implementation phase and unpracticable on the ongoing phase of the project.

5. PRELIMINARY REMARKS

5.1. Theoretical Foundation

Theoretical or practical knowledge, devoid of the means for its conservation and transmission, have a little meaning. Human work becomes material through procedures, rules, instructions and models, that can be repeated, taught and learned. Without this fundamental condition - the expression of knowledge in understandable rules by the others - material civilization is unable to reproduce itself. Teaching and learning are acts that require a common language to the process of creation (ABNT, 2011).

That common language as the assurance of procedures, rules, instructions, models, that could be repeated, is united in specific standards generated by some standards entity or governmental unit.

In 1926, the first international standardization entity - "International Federation of the National Standardizing Associations" (ISA) - was created, which ceased its activities in 1942, during World War II.

The acronym "ISO" refers to the International Organization for Standardization, created in 1946, after the end of the international conflict, when representatives from 25 countries met in London and decided to create a new organization for standardization, with the objective of "facilitating international coordination and unification of industry standards".

Brazil is represented at ISO by the Associação Brasileira de Normas Técnicas (ABNT), founded in 1940, being one of its signatory entities. ABNT is formed by committees and, particularly in the area of quality, there is the CB-025 - Brazilian Quality Committee, formed by study commissions, whose scope of activity involves standardization.

Nowadays, the current ISO 9000 standards set the ABNT NBR ISO 9001, released in 2015, is the current standard version available, and, in addition to the specific changes, it is in line with the ISO 14001:2015 Environmental Management System standard, which facilitates implementation by companies that work with the Integrated System of Management.

The Principles are slightly modified from previous versions and it highlights seven points: customer focus, leadership, people engagement, process approach, improvement, evidence-based decision making and relationship management. These values are the pillars of the organization's behavior, which is committed to the Quality Management System and should guide the actions of all employees, from operators to company management, mainly to the user of final consumer of services satisfaction.

5.1.1. Quality management principles

The standard is based on the quality management principles described in ABNT NBR ISO 9001. The descriptions include the declaration of each principle; the justification of why the principle is important to the organization; some examples of benefits associated with the principle; and examples of actions to improve the organization's performance when applying the principle.

The adoption of a quality management system is a strategic decision for an organization that can help to improve its global performance and provide a solid basis for sustainable development initiatives.

The potential benefits for an organization resulting from the implementation of a quality management system based on ISO9001 Standard are:

a) the ability to consistently provide products and services that meet customer requirements and applicable statutory and regulatory requirements;

b) facilitate opportunities to increase customer satisfaction;

c) address risks and opportunities associated with its context and objectives, and;

d) the ability to demonstrate compliance with specified quality management system requirements.

The standard can be used by internal and external parties.

The quality management system requirements specified in the standard are complementary to the requirements for products and services.

5.1.2. Process approach

The standard promotes the adoption of process approach in the development, implementation and improvement of the effectiveness of a quality management system, in order to increase customer satisfaction, by meeting customer requirements.

Understanding and managing interrelated processes, as a system, contributes to the organization's effectiveness and efficiency in achieving its intended results. This approach enables the organization to control the interrelationships and interdependencies between processes in the system, so that the overall performance of the organization can be high.

The process approach involves the definition and systematic management of processes and their interactions to achieve the intended results in accordance with the quality policy and suit as a strategic direction for the organization. Management of the processes and the system can be achieved using the PDCA cycle with a general focus on risk mentality, aiming to take advantage of opportunities and prevent undesirable results.

The application of the process approach in a quality management system provides:

a) understanding and consistency in meeting requirements;

b) consideration of processes in terms of added value;

c) the achievement of effective process performance;

d) improvement of processes based on the evaluation of data and information.

Figure 5 shows a schematic representation of a general process and the interactions of its elements. The monitoring and measurement points required for control are specific to each process and vary depending on the related risks.

The standard employs the process approach, which incorporates the Plan-Do-Check-Act (PDCA) cycle and the risk mentality. The process approach enables an organization to plan its processes and interactions.
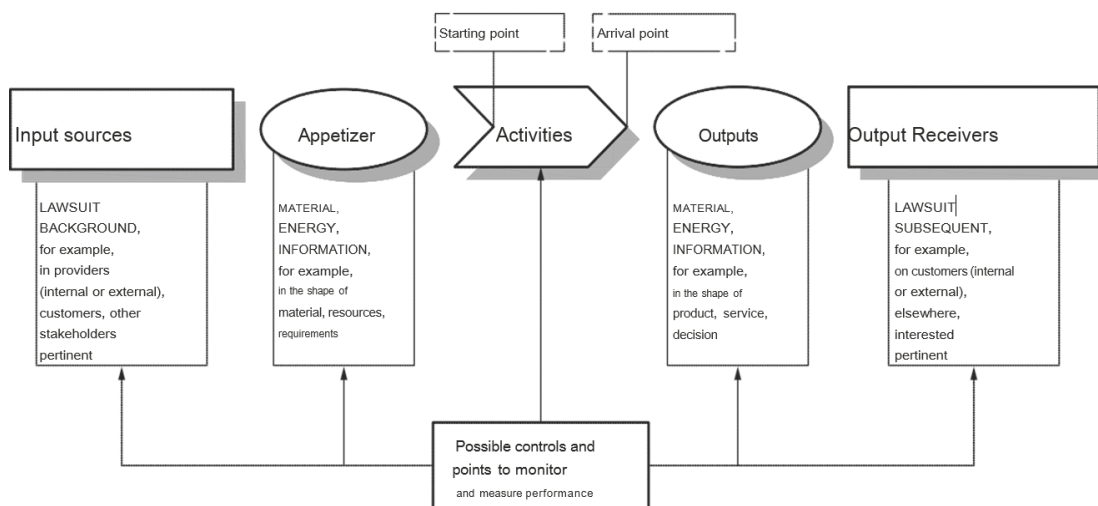
Figure 5 - Schematic representation of the elements of an individual process – From: ABNT NBR ISO9001:2015

The PDCA cycle enables the organization to ensure that its processes have enough resources and are properly managed; the opportunities for improvement are identified; and actions can be taken.

5.1.3. Cycle Plan-Do-Check-Act - PDCA

The PDCA cycle can be applied to all processes and to the quality management system. Figure 6 illustrates how standard sections can be grouped in relation to the PDCA cycle.
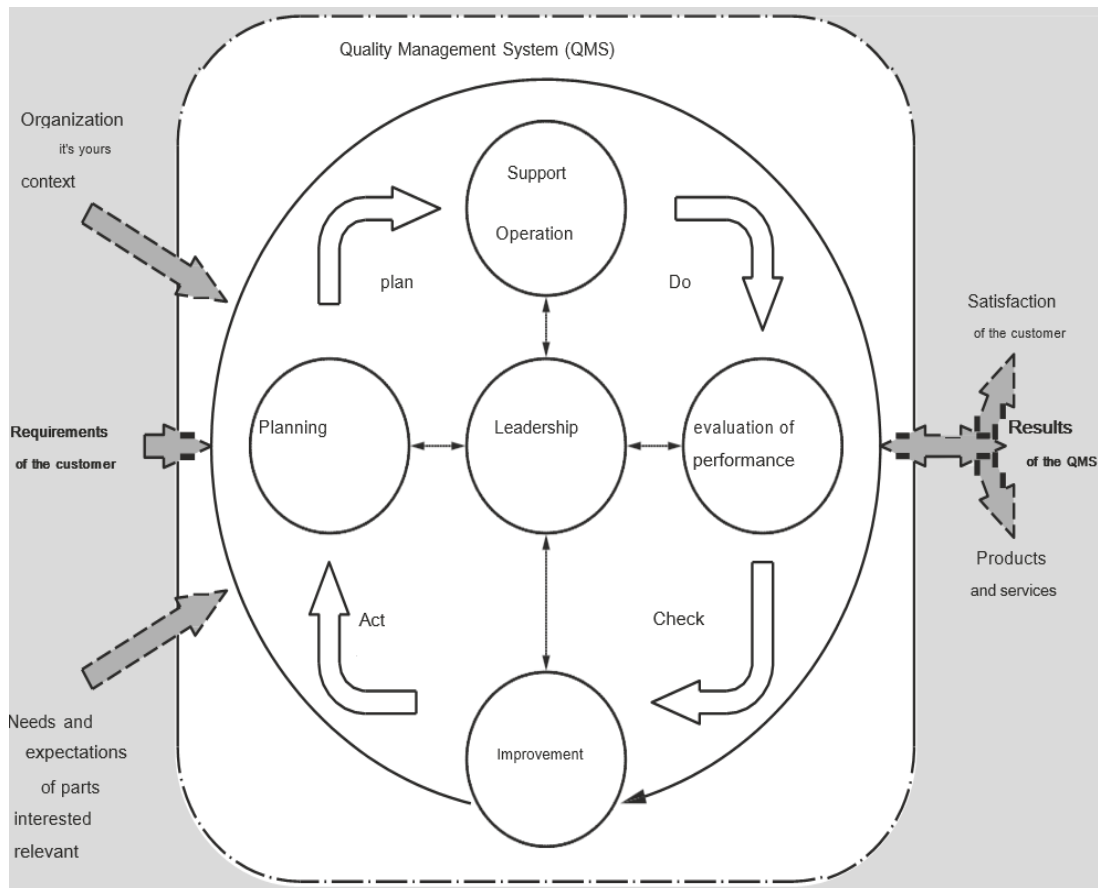
Figure 6. Representation of the structure of PDCA cycle in the standard – From: ABNT NBR ISO9001:2015

The PDCA cycle can be briefly described as follows:

- Plan: establish the objectives of the system and its processes and the necessary resources to deliver results in accordance with the requirements of the clients and the organization's policies;

- Do: implement what was planned;

- Check: monitor and (where applicable) measure the resulting processes, products and services against policies, objectives and requirements, reporting the results;

- Act: take actions to improve performance as needed.

With a risk mentality deployment, it is possible to enable the organization to determine the factors that could cause deviations in its processes and in its quality management system in relation to the planned results, to adopt preventive controls to minimize negative effects and to maximize the use of opportunities that arise.

5.1.4. Risk mentality

The risk mentality is essential to achieve an effective quality management system. The concept of risk mentality was implicit in previous versions of the standard, including, for example, taking preventive actions to eliminate potential non-conformities, analyzing all situations that occur and taking action to prevent recurrences that are appropriate to the effects of the non-conformity.

To comply with the requirements of the standard, an organization needs to plan and implement actions to address risks and opportunities. The approach to risks and opportunities establishes a basis for increasing the effectiveness of the quality management system, achieving improved results and for preventing negative effects.

Opportunities can arise as a result of a situation favorable to the achievement of an intended result, for example, a set of circumstances that enable the organization to attract customers, develop new products and services, reduce waste or improve productivity. Actions to address opportunities may also include consideration of associated risks. Risk is the effect of uncertainty, and can have a positive or negative effect. A positive deviation from a risk can offer an opportunity, but not all positive risk effects result in opportunities.

Consistently meeting requirements and addressing future needs and expectations is a challenge for organizations in a progressively dynamic and complex environment. To achieve this goal, the organization may consider it necessary to adopt various forms of improvement, in addition to correct its non-conformities and provide continuous improvement, such as change of rupture, innovation and reorganization.

5.1.5. Relationship with other management systems standards

The standard applies the framework developed by ISO to improve the alignment between its standards for management systems.

The standard enables an organization to use the process approach, combined with the PDCA cycle and risk assessment, to align or integrate its quality management system with the requirements of other management system standards.

The standard relates ABNT NBR ISO 9000 and ABNT NBR ISO 9004 as follows:

- ABNT NBR ISO 9000, Quality management systems - Fundamentals and vocabulary provides the essential basis for the proper understanding and implementation of the standard;

- ABNT NBR ISO 9004, Management for the sustained success of an organization - A quality management approach provides guidelines for organizations that choose to make progress beyond requirements of the standard.

5.2. Theoretical Background

In today's world, quality is not synonymous of exclusivity or superiority, since many companies offer quality products and services and adopt quality management through an internationally standardized management system.

According to Carpinetti (2012), quality is no longer a concept related only to technical aspects but has incorporated market demands and attributes to meet consumer requirements.

Human society has always depended on quality since the beginning of history, according to Juran (1988).

Lourenço Filho (1980) states that quality control is as old as the industry itself and for a long time it was carried out under the traditional form of inspection and, from 1920 on, statistical quality control was developed.

According to Toledo (1987), in the 1980s, quality was a key word within companies and quality control was understood as a department, that is, it was an element of the quality function. Quality control circles were commonplace and, in some companies, such as the aeronautical industry and nuclear power, a quality assurance sector exists.

There were two levels: the design quality and the conformation quality. At the time, standardization were mentioned, but not the term quality management, which was adopted after the 2000 revision of the ISO 9000 standards family.

According to Carvalho and Paladini (2012), normative documents such as standards, manuals, work instructions and procedures represent an evolution in the concept of quality. These documents reflect the knowledge acquired by society and allow its use by organizations as a way of producing by means a Quality Management System - QMS, generating products and services within specifications and standards in order to guarantee the quality defined and expected by the consumer.

According to Fogliatto and Ribeiro (2009), it is important to state that quality and reliability, besides their soft distinction, are two interrelated factors in the development of any project. (FOGLIATTO and RIBEIRO, 2009).

A QMS is a set of policies, processes and procedures required for planning and execution (production/development/service) in the core business area of an organization (i.e., areas that can impact the organization's ability to meet customer requirements). ISO 9001 is an example of a QMS.

5.2.1. Quality management systems - Requirements

The standard specifies requirements for a quality management system when an organization needs to demonstrate its ability to consistently provide products and services that meet customer requirements and applicable statutory and regulatory requirements.

All the requirements of the standard are generic and are intended to be applicable to any organization, regardless of its type or size, or the products and services it provides.

For the purposes of this work, the terms and definitions of ABNT NBR ISO 9000:2015 will be applied.

5.2.1.1. Context of the organization

The organization must determine external and internal issues that are relevant to its purpose and strategic direction and that affect its ability to achieve the intended result(s) of its quality management system.

The organization should monitor and critically analyze information on these external and internal issues. This may include positive and negative factors or any conditions considered suitable.

Understanding the external context can be facilitated by considering issues arising from the legal, technological, competitive, market, cultural, social and economic environments, both international, national, regional or local.

Understanding stakeholder needs and expectations

Due to its effect or potential effect on the organization's ability to consistently provide products and services that meet customer requirements and applicable statutory and regulatory requirements, the organization must determine the interested parties that are relevant to the quality management system, and their requirements

Determining the scope of the quality management system

The determination of the limits and the applicability of the quality management system to establish its scope is important to the organization.

When determining this scope, the organization should consider: i. the external and internal issues; ii. the relevant stakeholder requirements, and; iii. the organization's products and services.

The organization shall apply all the requirements on the standard, if they are applicable within the determined scope of its quality management system.

The scope of the organization's quality management system must be available and maintained as documented information. The scope must clearly declare the types of products and services covered and provide justification for any requirement of the standard that the organization determines is not applicable to the scope of its quality management system.

Compliance with ISO standard can only be claimed if requirements determined to be inapplicable do not affect the organization's ability or responsibility to ensure compliance with its products and services, and increasing customer satisfaction.

Quality management system and its processes

The organization must establish, implement, maintain and continuously improve a quality management system, including the necessary processes and their interactions.

The organization must determine the processes necessary for the quality management system and its application in the organization, and must:

- determine the required inputs and expected outputs of these processes;

- establish the sequence and interaction of these processes;

- determine and apply the criteria and methods (including related monitoring, measurements and performance indicators) necessary to ensure the effective operation and control of these processes;

- point the resources needed for these processes and ensure their availability;

- assign the responsibilities and authorities for these processes;

- address risks and opportunities as determined in accordance with requirements;

- evaluate these processes and implement any necessary changes to ensure that these processes achieve their intended results, and;

- improve quality management processes and systems.

To the extent necessary, the organization must maintain documented information to support the operation of its processes and retain documented information to be confident that the processes are carried out as planned.

5.2.1.2. Leadership

The top management of the company must demonstrate leadership and commitment to the quality management system:

- being responsible for rendering accounts for the effectiveness of the quality management system;

- ensuring that the quality policy and quality objectives are established for the quality management system and that they are compatible with the context and the strategic direction of the organization;

- assuring the integration of quality management system requirements into the organization's business processes;

- promoting the use of the process approach and the risk mentality;

- ensuring that the necessary resources for the quality management system are available;

- communicating the importance of effective quality management and complying with the requirements of the quality management system;

- warrant that the quality management system achieves its intended results;

- engaging, directing and supporting people to contribute to the effectiveness of the quality management system;

- promoting improvement;

- supporting other relevant management roles to demonstrate how their leadership applies to the areas under their responsibility.

Also the Senior Management must demonstrate leadership and commitment to customer focus, ensuring that the client's requirements and the relevant statutory and regulatory requirements are determined, understood and met consistently, the risks and opportunities that may affect the conformity of products and services and the ability to increase customer satisfaction are determined and addressed, and; the focus on increasing customer satisfaction is maintained.

5.2.1.3. Policy

The High Management must establish, implement and maintain a quality policy that is appropriate to the organization's purpose and context and supports its strategic direction. Providing a structure for establishing quality objectives that includes a commitment to meet applicable requirements, and a commitment to the continuous improvement of the quality management system.

The quality policy must be available and be maintained as documented information, being communicated, understood and applied in the organization, and should be available to relevant stakeholders, as appropriate.

Organizational roles, responsibilities and authorities

The top management should ensure that responsibilities and authorities for relevant roles are assigned, communicated and understood within the organization. The Senior Management should assign responsibility and authority to:

- ensure that the quality management system complies with the requirements of the standard;

- assure that the processes deliver their intended outputs;

- report on the performance of the quality management system and the opportunities for improvement, in particular to senior management;

- ensure the promotion of customer focus in the organization, and;

- warrant that the integrity of the quality management system will be maintained when changes to the quality management system are planned and implemented.

5.2.1.4. Planning

When planning the quality management system, the organization should consider the issues and the requirements, and determine the risks and opportunities that need to be addressed to ensure that the quality management system can achieve its intended results, increasing desirable effects,by preventing or reducing undesirable effects, achieving its improvement.

The organization should plan actions to address these risks and opportunities as integrate and implement actions in the processes of your quality management system, evaluating the effectiveness of these actions.

Actions taken to address risks and opportunities must be appropriate to the potential impact on product and service compliance.

Options for addressing risks may include avoiding risk, taking risk to pursue an opportunity, eliminating the source of risk, changing the probability or consequences, sharing the risk or deciding, based on information, to retain the risk.

Opportunities can lead to the adoption of new practices, launching new products, opening new markets, approaching new customers, building partnerships, using new technologies and other desirable and viable possibilities to address the needs of the organization or its customers.

Quality objectives and planning to achieve them

The organization must establish quality objectives in the relevant functions, levels and processes necessary for the quality management system, and they should:

- be consistent with the quality policy;

- be measurable;

- consider applicable requirements;

- be relevant to the conformity of products and services in order to increase customer satisfaction;

- be monitored;

- be communicated, and;

- be updated as appropriate.

The organization must maintain documented information on quality objectives. When planning how to achieve its quality objectives, the organization must determine what will be done, what resources will be required. Also, who will be responsible and when will be completed. Then, establish how the results will be evaluated.

Change planning

If needed, the organization should determine the changes into the quality management system, and it must be made in a planned and systematic manner, taking in consideration the purpose of the changes and their potential consequences, the integrity of the quality management system, the availability of resources, and, the allocation or reallocation of responsibilities and authorities.

5.2.1.5. Support

To determine and provide the necessary resources for the establishment, implementation, maintenance and continuous improvement of the quality management system, the organization must aim the capacities and restrictions of existing internal resources and point what needs to be obtained from external providers.

The organization must determine and provide the people necessary for the effective implementation of its quality management system and for the operation and control of its processes.

Also, it must determine, provide and maintain the necessary infrastructure for the operation of its processes and achieve product and service compliance, including i. buildings and associated utilities; ii. Software and equipment, including

materials, machines, tools, etc.; iii. transport resources, and; iv. information and communication technology.

Should be granted, provided and maintained the necessary control environment for the operation of its processes and to achieve product and service compliance.

A suitable environment can be a combination of human and physical factors, such as social (for example, non-discriminatory, calm, non-confrontational), psychological (for example, stress reducer, preventive to exhaustion, emotionally protective) and physical (for example, temperature, heat, humidity, light, airflow, hygiene, noise).These factors may differ substantially, depending on the products and services provided.

When measurement traceability is a requirement or is considered by the organization to be an essential part of providing confidence in the validity of measurement results, measurement equipment is needed.

It should be verified or calibrated, or both, at specified intervals, or before use, against measurement standards traceable to international or national measurement standards; when such standards do not exist, the basis used for calibration or verification should be retained as documented information, and must be identified to determine their situation and safeguarded against adjustments, damage or deterioration that would invalidate the calibration situation and subsequent measurement results.

The organization shall determine whether the validity of previous measurement results has been adversely affected when the measurement equipment is found to be inappropriate for its intended purpose and must take appropriate action as necessary.

The organization must determine the knowledge required to operate its processes and to achieve product and service compliance. This knowledge must be maintained and available to the extent necessary.

In addressing changing needs and trends, the organization must consider its knowledge at the time and determine how to acquire or access any necessary additional knowledge and required updates.

Organizational knowledge is specific for the organization; it is obtained by experience and benchmark of external sources. It is information that is used and shared to achieve the organization's goals.

Organizational knowledge can be based on:

- internal sources (for example, intellectual property; knowledge obtained from experience; lessons learned from failures and from successful projects; capture and sharing of undocumented knowledge and experience; the results of improvements in processes, products and services), and;

- external sources (for example, standards; academia; conferences; compilation of knowledge from customers or external providers).

Competence

The organization need to determine the necessary competence of the person(s) to perform work under their control that affects the performance and effectiveness of the quality management system ensuring that these people are competent, based on appropriate education, training or experience. When applicable, taking actions to acquire the necessary competence and, after, evaluating the effectiveness of the actions taken and retaining documented information, is an appropriate evidence of competence.

Applicable actions may include, for example, provision of training; mentoring or changing the assignments of people currently employed; or employ or hire competent authorities.

Awareness

The organization must ensure that people who perform work under the organization's control are aware of the quality policy, the relevant quality objectives and its contribution to the effectiveness of the quality management system, including the benefits of improved performance and implications of not complying with the requirements of the quality management system.

Communication

It shall be determined the internal and external communications, relevant to the quality management system, including:

- what to communicate;

- when to communicate;

- with whom to communicate;

- how to communicate, and;

- who communicate.

Documented information

The organization's quality management system should include documented information required by the standard and determined by the organization to be necessary for the effectiveness of the quality management system.

The extent of the documented information for a quality management system may differ from one organization to another due to:

- the size of the organization and its type of activities, processes, products and services;

- the complexity of processes and their interactions, and;

- the competence of individuals.

When creating and updating documented information, the organization must ensure appropriate identification and description (for example: titles, date, author or reference number), the format (for example, language, version of software, graphics) and a means (for example, paper, electronic) and critical analysis and approval as to adequacy and sufficiency.

The documented information required by the quality management system and the standard should be controlled to ensure that it is available and suitable for use, where and when it is needed and if it is sufficiently protected (for example, against loss of confidentiality, misuse or loss of integrity).

For the control of documented information, the organization must address the following activities, as applicable:

- distribution, access, recovery and use;

- storage and preservation, including legibility;

- change control (for example, version control), and;

- retention and disposition.

External documented information, determined by the organization as necessary for the planning and operation of the quality management system, must be identified, as appropriate, and controlled.

Documented information retained as evidence of compliance must be protected from unintended changes. Access may imply a decision on whether to only view documentary information or permission and authority to view and change documented information.

5.2.1.6. Operation

The organization must plan, implement and control the necessary processes to meet the requirements for the provision of products and services once established, and to implement the actions determined previously in the QSM premises, establishing criteria and acceptance for products and services, and also determining the resources needed to achieve compliance with product and service requirements and implement process control according to criteria.

The organization must determine and retain documented information to the extent necessary to have confidence that the processes were conducted as planned, and, demonstrate the compliance of products and services with your requirements. Thus, the output of this planning must be adequate for the organization's operations.

The organization must monitor planned changes and critically analyze the consequences of unintended changes, taking actions to mitigate any adverse effects, as necessary and ensure that outsourced processes are controlled.

Requirements for products and services

The communication with customers, should work in providing information regarding products and services, handle inquiries, contracts or orders, including exchanges. Also, it is used to obtain customer feedback on products and services, including customer complaints, handle or control the customer's property and establish specific requirements for contingency actions, when applicable.

In determining the requirements for the products and services to be offered to customers, the organization must ensure that the requirements for products and services are defined, including any applicable statutory and regulatory requirements, also those considered necessary by the organization to meet the demands for the products and services it offers.

The organization must ensure that it's able to meet the requirements for products and services to be offered to customers. The organization must conduct a critical review before committing to provide products and services to its customer, and should include:

- requirements specified by the customer, considering, also, delivery and post-delivery activities;

- requirements not stated by the customer, but necessary for the specified or intended use, when known;

-requirements specified by the organization;

- statutory and regulatory requirements applicable to products and services, and;

- contract or order requirements other than those previously expressed.

The organization must assure that contract or order requirements different from those previously defined are resolved. The customer's requirements must be confirmed by the organization prior to acceptance, when the customer does not provide a documented statement of its requirements.

In some situations, such as sales by Internet, a formal review for each order it is impractical. In such cases, the critical analysis may include information relevant to the product, such as catalogs.

The organization must retain documented information, as applicable, about the results of the critical analysis and any new requirements for products and services, ensuring that relevant documented information is amended, and the relevant individuals are alerted to changed requirements, when requirements for products and services are changed.

Design and development of products and services

The organization must establish, implement and maintain a design and development process that is appropriate to ensure the subsequent provision of products and services.

In determining the stages and controls for design and development, the organization must consider:

- the nature, duration and complexity of the design and development activities;

- the required process stages, including applicable design and development reviews;

- the required design and development verification and validation activities;

- the responsibilities and authorities involved in the design and development process;

- the internal and external resources necessary for the design and development of products and services;

- the need to control interfaces between people involved in the design and development process;

- the need to involve customers and users in the design and development process;

- the requirements for the subsequent provision of products and services;

- the level of control expected for the design and development process by customers and other relevant stakeholders;

- the documented information needed to demonstrate that the design and development requirements have been achieved.

The organization must determine the essential requirements for the specific types of products and services to be designed and developed. It should consider functional and performance requirements, information derived from similar previous design and development activities, statutory and regulatory requirements, standards or codes of practice that the organization has committed to implement and, potential consequences of failures due to the nature of products and services.

Entries must be suitable for design and development purposes, complete and unambiguous. Conflicting design and development inputs must be resolved. documented information from design and development inputs must be retained.

The organization must apply controls to the design and development process to ensure results to be defined and achieved. A critical analysis should be conducted to assess the ability of design and development results to meet requirements.

The verification activities are conducted to ensure that the design and development outputs meet the input requirements. Validation activities are conducted to ensure that the resulting products and services meet the requirements for the specified application or intended use.

Any necessary actions must be taken on the problems encountered during the review or verification and validation activities, and documented information about these activities must be retained.

Critical analysis of design and development, verification and validation have different purposes. They can be conducted separately or in any combination, as it is appropriate for the organization's products and services.

The organization must ensure that design and development outputs meet the entry requirements, and also are suitable for the subsequent processes for the provision of products and services, and should include or reference monitoring and measurement requirements, as appropriate, and acceptance criteria, specifying the characteristics of the products and services that are essential for the intended purpose and their safe and appropriate provision.

The organization must identify, critically analyze and control the changes made during, or subsequently to, the design and development of products and services, to the extent necessary to ensure that there is no adverse impact on compliance with requirements.

The organization must retain documented information about:

- changes in design and development;

- the results of critical analyzes;

- the authorization of changes;

- the actions taken to prevent adverse impacts.

Control of processes, products and services provided externally

The organization must ensure that processes, products and services provided externally comply with requirements previously defined. The controls must be determinate to be applied to the processes, products and services externally provided when:

- products and services of external providers are intended to be incorporated into the organization's own products and services;

- products and services are provided directly to the customer(s) by external providers on behalf of the organization, and;

- a process, or part of a process, is provided by an external provider as a result of an organization's decision.

The organization must determine and apply criteria for the evaluation, selection, performance monitoring and reassessment of external suppliers, based on their ability to provide processes or products and services according to requirements estabilished. The organization must retain documented information about these activities and any necessary actions resulting from the assessments.

The organization will ensure that processes, products and services provided externally do not adversely affect the organization's ability to consistently deliver compliant products and services to its customers, and also must ensure that externally provided processes remain under the control of its quality management system, define both the controls it intends to apply to an external provider and those it intends to apply to the resulting outputs. Considering the potential impact of processes, products and services provided externally on the organization's ability to consistently meet customer requirements and statutory and regulatory requirements and the effectiveness of the controls applied by the external provider. Thus, it has to determine the verification, or other activity, necessary to ensure that the processes, products and services provided externally meet requirements.

The organization must ensure enough requirements before communicating to the external provider, and must communicate to external providers its requirements for the processes, products and services to be provided.

It should be controlled and monitored the performance of the external provider to be applied by the organization, and also is needed a verification or validation of activities that the organization, or its customers, intend to perform on the premises of the external provider.

Production and service provision

The organization must implement production and service provision under controlled conditions, that should include, as applicable:

- the availability of documented information that defines the characteristics of the products to be produced, the services to be provided or the activities to be performed, elucidating the results to be achieved;

- the availability and use of adequate monitoring and measurement resources;

- the implementation of monitoring and measurement activities at appropriate stages to verify which criteria for controlling processes or outputs and acceptance criteria for products and services have been met;

- the use of adequate infrastructure and environment for the operation of the processes;

- the designation of competent individuals, including all qualifications required;

- a periodic validation and revalidation of the ability to achieve planned results of processes for production and service provision, where it is not possible to verify the resulting output by subsequent monitoring or measurement;

- the implementation of actions to prevent human error, and;

- the implementation of release, delivery and post-delivery activities.

The use appropriate means is needed to identify ways-out when it is necessary to ensure the conformity of products and services.

The organization must identify the status of the outputs due to the monitoring and measurement requirements throughout production and service provision.

It's necessary to control the individual identification of the outputs when traceability is a requirement and must retain the documented information necessary to enable traceability.

The organization must take care of property belonging to external customers or providers, while it is under the organization's control or being used by the organization. It must identify, verify, protect and safeguard the inner property of customers or external organizations, provided for the use or incorporation in products and services.

When the property of a customer or external provider is lost, damaged or otherwise found to be unsuitable for use, the organization must report this to the customer or external provider and retain documented information about what has occurred.

An external customer or provider property may include material, components, tools and equipment, customer facilities, intellectual property and personal data. Also,

the organization must preserve outputs during production and service provision to the extent necessary to ensure compliance with requirements. Preservation may include identification, handling, contamination control, packaging, storage operation, transmission or transport and protection.

The organization must meet the requirements for post-delivery activities associated with the products and services.

In determining the extent of required post-delivery activities, the organization should consider:

- statutory and regulatory requirements;

- the potential undesirable consequences associated with your products and services;

- the nature, use and intended life of your products and services;

- customer requirements, and;

- customer feedback.

Post-delivery activities may include actions under warranty provisions, contractual maintenance and supplementary services obligations, such as recycling or final disposal. Also, the organization must review and control changes to production or service provision to the extent necessary to ensure continuous compliance with requirements, retaining documented information, which describes the results of the change reviews, the people who authorize the change and any necessary actions arising from the review.

Release of products and services

The organization should implement planned arrangements, at appropriate stages, to verify that the product and service requirements have been met.

The release of products and services to the customer cannot proceed until the planned arrangements have been satisfactorily completed, unless already approved by the relevant authority and, as applicable, by the customer.

The organization must retain documented information on the release of products and services. Documented information should include evidence of compliance with the acceptance criteria and traceability to the person(s) who authorize the release.

Control of non-compliances

The organization must ensure products or services issue that do not comply with its requirements are identified and controlled to prevent their unintended use or delivery.

Is necessary to take appropriate actions based on the nature of the non-compliance and its effects on product and service compliance. This should also apply to non-compliant products and services detected after delivery of products, during or after the provision of services.

The organization must deal with non-compliant exits in one or more of the following ways:

- correction;

- segregation, containment, return or suspension of the provision of products and services;

- information to the customer, and;

- obtaining authorization for acceptance under concession.

Compliance with requirements must be verified when non-compliant outputs are corrected.

The documented information that describe the non-compliance, the actions taken the concessions obtained and identify the authority that decides the action with respect to non-compliance, must be retained.

5.2.1.7. Performance evaluation

It must be determine what needs to be monitored and measured, the methods for monitoring, measurement; the analysis and evaluation necessary to ensure valid result; when monitoring and measurement should be carried out; and when the results of monitoring and measurement should be analyzed and evaluated.

The organization must assess the performance and effectiveness of the quality management system and must retain appropriate documented information as evidence of the results.

The organization should monitor customers' perceptions based on their needs and expectations level of acceptance. It must determine the methods for obtaining, monitoring and critically analyzing this information.

Examples of monitoring customer perceptions may include customer surveys, customer feedback on delivered products or services, meetings with customers, market share analysis, praise level, warranty claims and distributor reports.

The organization shall analyze and evaluate appropriate data and information from monitoring and measurement. It can include statistical techniques. Analysis results should be used to assess:

- product and service compliance;

- the level of customer satisfaction;

- the performance and effectiveness of the quality management system;

- whether the planning was implemented effectively;

- the effectiveness of the actions taken to address risks and opportunities;

- the performance of external providers;

- the needs for improvements in the quality management system.

Internal audit

The organization should conduct internal audits at planned intervals to provide information on whether the quality management system:

- complies with the organization's own requirements for its quality management system and the requirements of the standard;

- is implemented and maintained effectively.

The organization must plan, establish, implement and maintain an audit program, including the frequency, methods, responsibilities, requirements for planning and reporting, which must take into account the importance of the processes involved, changes affecting the organization and the results of previous audits. It must take into account to:

- define the audit criteria and the scope for each audit;

- select auditors and conduct audits to ensure the objectivity and impartiality of the audit process;

- ensure that the results of the audits are reported to the relevant management; perform appropriate corrections and corrective actions without undue delay, and;

- retain documented information as evidence of the implementation of the audit program and audit results.

Management review

Critical analysis by management must be planned and carried out considering the situation of actions resulting from previous critical analyzes by management and changes in external and internal issues that are relevant to the quality management system.

Information on the performance and effectiveness of the quality management system must be observed, including trends relating to customer satisfaction and feedback from relevant stakeholders, extent to which quality objectives have been achieved; process performance; product and service compliance; non-conformities and corrective actions, monitoring and measurement results; audit results, and; performance of external providers.

It also needs to observe the sufficiency of resources, the effectiveness of actions taken to address risks and opportunities and opportunities for improvement.

The outputs of the critical analysis by management must include decisions and actions related to opportunities for improvement, any needs for changes in the quality management system and needs for appeal.

The organization must retain documented information as evidence of the results of critical analysis by management.

5.2.1.8. Improvement

The organization must determine and select opportunities for improvement and implement any actions necessary to meet customer requirements and increase its leve of satisfaction, including improved products and services to meet requirements as well as to address future needs and expectations, or correct, prevent or reduce unwanted effects, improving the performance and effectiveness of the quality management system.

Examples of improvement can include correction, corrective action, continuous improvement, revolutionary changes, innovation and reorganization.

Non-compliance and corrective action

When non-compliance occurs, including those arising from complaints, the organization must react to non-compliance and, as applicable, take action to control and correct it, dealing with the consequences.

Also, it has to evaluate the needs for action to eliminate the cause(s) of the verified non-compliance, yy analyzing critically and analyzing non-compliance, determining the causes of non-compliance and determining whether similar non-conformities exist, or whether they could potentially to occur so that it does not recur or occur elsewhere.

A non-compliance occurrence still needs to implement any necessary action, critically analyze the effectiveness of any corrective action taken, update risks and opportunities determined during planning, and make changes to the quality management system, if necessary. Corrective actions must be appropriate to the effects of the non-conformities identified.

The organization must retain documented information as evidence relative to the nature of the non-conformities and any subsequent actions taken and the results of any corrective action.

Continuous improvement

The organization must continually improve the adequacy, sufficiency and effectiveness of the quality management system.

It should consider the results of analysis and evaluation and the outputs of critical analysis by management to determine whether there are needs or opportunities that should be addressed as part of continuous improvement.

5.3. Critical Review

Although the standard dedicates one entire chapter to directly specify the importance of the leadership to succeed in quality management improvement or implementation, all other sections make sure that this role cannot be ignored in any step of the project, and remains as a conditional factor regarding continuous improvement.

Considering the special nature of the company, in terms of governance, the leadership involved is a bottleneck in this project that, indirectly, limits the timeframe of opportunity to certify the company.

This correlation is due to the causal relationship between the change of the board of the company and the change of local government, which occurs every four years with local elections for the executive branch. Once the timeframe, for the project succeed to the initial phase (certification and firsts audits) takes a multiyear period, it is important to prevent changes in the Company's priorities.

Leadership also is a barrier breaker concerned to the current culture of organization (JASKYTE, 2004), being a fundamental agent of moving the status quo of a team that, in majority, has 20 year of experience cumulated in Rolling Stock Maintenance.

This consideration enables to sentence that the best opportunity window to guarantee the interest to complete all steps needed to ensure the implementation of a QMS is by the very first year of an elected government.

Another limitation due the nature of the company regards to the predictability of the budget in terms of an entire fiscal year. Since there is no legal margin to make changes in the Annual Budget (or, at least, it is a hard process that involves the Legislative Chamber), it is strongly not recommended to outsource the entire monitoring of the process. Since the standard allows this task to be made by critical meetings, this is possibly the best way to keep the project in touch with the initial budget, keeping external only the certification itself and the mandatory audits.

Understanding the limitations of the public nature of the company, it is also remarkable that the technical nature of the company also brings opportunities and shortcuts for the implementation of QMS.

Mass transportation systems are strongly connected to a risk mentality. Almost the entire statements and requirements preconized by ISO are, even not formally stated in standard's basis, well rooted and solidified in all process and tasks developed internally on company.

The concept of failsafe design permeates the technical development of rail systems since the early 1900s (SOLOMON, 2010). It means that, since the concept phase to the operational life, the vital systems are thought in a way that the requirement of having the safety as a priority is not optional for professionals working on operation and maintenance of those systems.

Consequence of the intrinsic culture of railroad systems, documentation of processes are also a strong factor in Rolling Stock Industry, in general.

5.4. Scope and limitations

As explained in earlier chapter, the implementation plan proposed in this work will focus on its application over Rolling Stock maintenance only.

Among the various systems and equipment that make up the Metro System of the Federal District, it was decided to choose only one of them to implement Quality Management in its internal maintenance processes.

This decision is justified by the fact that the certification process is long and expensive, and, considering that the current METRÔ-DF technical team does not yet have experience with this topic, as well as the current budget and financial limitations of the Company, it is now necessary to implement a pilot project in a single system. At the end of the implementation, and after a certain period observing the results of the ISO 9001 implementation, the technical and financial feasibility for expanding the quality management to the other systems can be evaluated.

The chosen system is the rolling stock of the METRÔ-DF. This is composed, as stated in another chapter of this project, by 32 trains, where 20 of them are Series 2000 and 12 of them are Series 1000, manufactured in the mid-1990s and in the years 2010/2011, respectively, both from the manufacturer ALSTOM.

The figures 7 and 8 shows the Metrô-DF trains:

Figure 7. Fleet 1000 Train.

Figure 8. Fleet 2000 Train.

This fleet represents the Company's identity for passengers, as it is one of the Systems with more interaction, for using it as a means of transport and which requires excellent performance. However, Series 1000 trains require more detailed technical monitoring and a greater number of interventions, given their time of manufacture, and Series 2000 trains require interventions with greater efficiency to avoid an early end of life.

Of the total of 485 existing maintenance procedures for all Systems, as already informed, the 1000 and 2000 Series trains have 150 procedures in place, that is, about 30% of all documented maintenance activities are focused on Rolling Stock. In addition, of the 44,875 service orders carried out until September this

year, 18,031 service orders (40% of the total) were carried out in the maintenance activities of the trains, namely: preventive and corrective maintenance, workshops issues, tests, visual inspections and deep inspection.

The direct maintenance costs of these trains are in the order of R$ 21,000,000.00 (Twenty one million reais) per year, referring to the maintenance contract signed between METRÔ-DF and the company MPE ENGENHARIA for continuous maintenance services. This amount does not include costs with METRÔ-DF teams and other administrative support activities for maintenance, as well as the necessary investments for the acquisition of spare parts. The warehouse to support these activities is evaluated in over R$ 19.860.261,47.

In view of the technical reasons exposed and the high maintenance costs, the choice of the Rolling Stock System as a pilot project for the implementation of Quality Management in METRÔ-DF is justified.

5.5. Literature Review

In this chapter, it will be shown that the main operators of the Brazilian Metro rail sector have Quality Management certification and that guided this study.

In 2003, the São Paulo Metro was the second in the world to receive ISO 9001 certification, version 2000, which ensures the quality of its services throughout its network, at that time. As reported, the first subway to receive this certification was Hong Kong. (METRÔ-SP, 2003)

In order to implement and achieve this certification, Companhia do Metropolitano de São Paulo trained about four thousand employees in dozens of different jobs. The implantation process was carried out considering the user's vision and encompassing all the processes and procedures involved from its entry in the system until its exit, during the trip. (METRÔ-SP, 2003).

In 2013, MetrôRio, the concessionaire responsible for the operation and maintenance of the Rio de Janeiro city metro system, achieved ISO 9001 certification (MetrôRio, 2014).

ViaQuatro, the company that operates Line 4-Yellow of the subway, obtained in 2013 the ISO 9001: 2008 certification. The implementation process of this Quality Management System at ViaQuatro, certified by the company SGS do Brasil, lasted two years with the participation of all company employees. In order to maintain certification, the company will undergo an internal audit cycle as well as maintenance audits carried out by the SGS certifier, which initially carried out the certification. (ViaQuatro, 2013)

In 2016, CCR Metrô Bahia, responsible for the subway in the cities of Lauro de Freitas and Salvador, in the State of Bahia, obtained the certification of the Quality Management System in the NBR ISO 9001 standard, by the certifying entity Bureau Veritas Certification. The concessionaire seeks to believe that it has taken an important step towards ensuring the quality of the provision of a public transport service as well as its commitment to the continuous improvement of its processes and the promotion of a healthy and safe environment for its employees, partners and users. (CCR Metrô Bahia, 2016)

Companhia Paulista de Trens Metropolitanos - CPTM also has ISO 9001 certification, whose quality policy is to promote public and operational quality security, aiming at the continuous improvement of its processes and the satisfaction of its customers. (CPTM, 2020)

According to research carried out, there are other railway passenger transport operators that do not have certification in the Quality Management System, as well as METRÔ-DF.

In the next chapters of the present work, studies on risk and cost analysis as well as the implementation plan for this standardization in the Rolling Stock System of METRÔ-DF will be presented.

6. COST BENEFIT ANALYSIS

In order to carry out an assessment, the Cost Benefit Analysis (CBA) focuses on assessing the impacts arising from the implementation of the project evaluated on the rolling stock maintenance. This means that, depending on the result of the assessment, making investments can be justified with the objective of increasing economic utility for the company, reducing the costs of maintenance procedures an rising the availability of rolling stock.

A cost-benefit analysis (CBA) should begin with compiling a comprehensive list of all the costs and benefits associated with the project or decision.

The costs involved in a CBA might include:

- Direct costs would be direct labor involved in manufacturing, inventory, raw materials, manufacturing expenses.

- Indirect costs might include electricity, overhead costs from management, rent, utilities.

- Intangible costs of a decision, such as the impact on customers, employees, or delivery times.

- Opportunity costs such as alternative investments or buying a plant versus building one.

- Cost of potential risks such as regulatory risks, competition, and environmental impacts.

Benefits might include:

- Revenue and sales increases from increased production or new product.

- Intangible benefits, such as improved employee safety and morale, as well as customer satisfaction due to enhanced product offerings or faster delivery.

- Competitive advantage or market share gained as a result of the decision.

An analyst or project manager should apply a monetary measurement to all of the items on the cost-benefit list, taking special care not to underestimate costs or overestimate benefits. A conservative approach with a conscious effort to avoid

any subjective tendencies when calculating estimates is best suited when assigning a value to both costs and benefits for a cost-benefit analysis.

Finally, the results of the aggregate costs and benefits should be compared quantitatively to determine if the benefits outweigh the costs. If so, then the rational decision is to go forward with the project. If not, the business should review the project to see if it can make adjustments to either increase benefits or decrease costs to make the project viable. Otherwise, the company should likely avoid the project.

Investment costs were obtained based on benchmarking carried out on similar practices about ISO9001 certification process in order to accomplish the NBR ABNT ISO9001 practiced mainly at the national level in the recent time, as model was used by CHESF, a Brazilian energy company, to a tender that we used main cost elements described below:

a) Taxes

- Registration License use trademark Inmetro: according to inter-ministerial ordinance no. 44, of January 27, 2017.

- Original copies of the License Registration use of the INMETRO trademark: in partnership with the Quality Committees ABNT / CB-25 and ABNT / CB-38 Inmetro aims to make available to society in general, in an efficient, transparent and centralized way, information on the certificates issued in Brazil by certification bodies accredited by Inmetro in the systems quality management (ISO 9001) and environmental management (ISO 14001).

b) Audits

- Document analysis: as mentioned earlier there's about 150 documented procedures about rolling stock maintainment in the company, and, everyone will be reviewed to keep standard regulation.

- Initial Audit: diagnosis of actual situation and establishment of audit plan and procedures.

- Audit Certification Areas (1 year): assessment of accomplishment of standards requirements in areas involved in rolling stock maintenance.

- Audit Maintenance / Monitoring Areas (2nd and 3rd year): internal compliance monitoring of standards requirements in areas involved in rolling stock maintenance.

- Follow-up audit (by certifier's office): monitoring audit of the obtained certification.

c) Other expenses

- Travel and training expenses: costs involved with certification external auditor travels from headquarters office and training programs to internal auditors.

Table 1. Estimated costs for certification.

Taxes	Costs/ Year		
	1st Year	2nd Year	3rd Year
Registration License use trademark INMETRO	R$ 1.352,74	-	-
Original copies of the License Registration use of the INMETRO trademark	R$ 2.067,00	-	-
Total of Taxes	R$ 3.419,74		
Audits			
Document analysis	R$ 70.342,48	R$ 70.342,48	R$ 63,578,78
Initial Audit	R$ 2.705,48	-	-
Audit Certification Areas (1 year)	R$ 22.996,58	-	-
Audit Maintenance / Monitoring Areas (2nd and 3rd year)	-	R$ 20.291,10	R$ 18.938,36
Follow-up audit (certifier's office)	-	R$ 2705,48	$ 2705,48
Total of Audits	R$ 96.044,54	R$ 93.339,06	R$ 85.222,62
Other expenses			
Travel and training expenses	R$ 21.643,84	R$ 18.938,36	R$ 16.232,88
Total / Year	R$ 121.108,12	R$ 112.277,42	R$ 101.455,50
		GRAND TOTAL	R$ 334.841,04

At Table 1 is possible to see a cost estimate for NBR ISO9001 certification of Rolling Stock maintenance procedures. From the cost estimate it is possible to obtain a cash flow for the project. Table 2 shows the variation in cash flow over five years.

Table 2. Project Cash Flow

Project Cash Flow					
	Yr1	Yr 2	Yr3	Yr4	Yr5
Cash Inflow	-	-	R$ 66.000,00	R$ 132.000,00	R$ 264.000,00
Cash Outflow	(R$ 121.108,12)	(R$ 112.277,42)	(R$ 101.455,50)	-	-
Net Cash Flow Value	(R$ 121.108,12)	(R$ 233.385,54)	(R$ 268.841,04)	(R$ 136.841,04)	R$ 127.158,96

As a cash inflow value, reduction in penalties were considered, due to maintenance failures reduction or reduction of not complied failures in any procedure or omissions, it's believed that will be due to standardization with improvement of quality and risk mitigation by implementation of a QMS (Casadesús, Giménez e Heras, 2001).

Such these direct benefits are assumed as progressive at a rate that could be doubling each year of the certification is implemented because today penalties are part of the contract risk and in the future it could be evaluated as a reduction in a new contract after the benefits of ISO certification.

Nowadays METRO-DF have an average penalty value of R$ 1.320.000 per year and is reasonable to estimate, starting at third year of certification project, that it is possible to reduce penalties in about a rate of 5% and is expected the values doubles each year since that year.
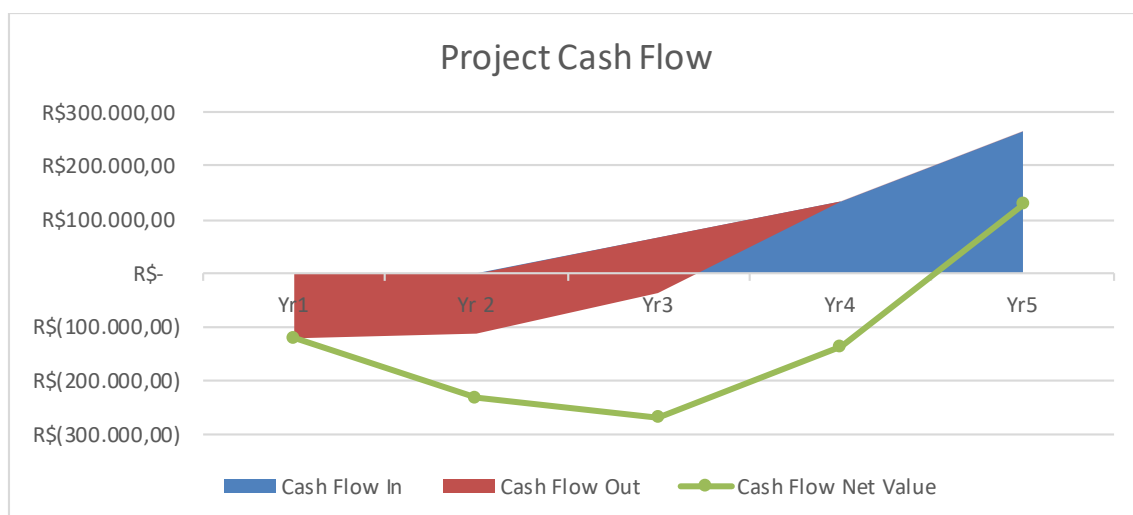
Figure 9. Project Cash Flow graph representation

As another direct benefit, it is possible to take into account the reduction in waste of materials and time to accomplish maintenance procedures, although it's not possible to measure it properly, but penalties could be a good proxy cost to evaluate that.

Indirect benefits could be multiple to account as it could impact the operation in a positive way, and one of main aspect of that kind of benefits is the raise of disponible rate of rolling stock and reduction of failures, that impacts directly in the offer and raise of demand, what reflects in an increment in revenues and more confidence from system users.

Based on the parameters for estimating costs and with cash flow presented, the next step consists of obtaining and analyzing the results of the evaluation of expected benefits and estimated costs based on Net Present Value Criterion (NPV).

The total cost of the project represents 1,6% of the rolling stock maintenance that costs an average value of R$ 21.000.000 per year, and the direct impact of project, represented by penalties reduction, is sufficient to payback the project costs at 5th year as could be seen at cashflow, therefore, was not considered indirect benefits to estimate the benefit/cost value.

The benefit/cost technique transports the values of a cash flow to the zero date as shown in equation 1 (base year), discounting them at a rate equivalent to the weighted average cost of capital. The project will be considered viable when the result measured through the net present value is positive.

$$NPV = \sum \frac{Bt}{(1+i)^t} - \sum \frac{Ct}{(1+i)^t} \qquad (1)$$

Where:

NPV: net present value

Bt: expected benefits in period t;

Ct: expected costs in period t;

t: period of analysis, in number of years from the base year;

i: discount rate (used 5.2%, risk-free rate represented by national treasury bills, based on the treasury yield rate IPCA);

After estimate of five years the project have a positive NPV of R$ 60.362,5 based on cash flow presented.

As with the NPV technique, the costs and benefits are discounted at a given rate by comparing the relationship between them, as shown in the equation 2 below:

$$NPV = \frac{\Sigma \frac{Bt}{(1+i)^t}}{\Sigma \frac{Ct}{(1+i)^t}} > 1 \qquad (2)$$

Where B / C is the ratio between benefits and costs of the project. The project is considered economically viable if the B / C ratio is greater than 1, that is, the benefits outweigh the costs. The current project has a B/C ratio of 1,2 what means the project benefits outweigh the breakeven in 20%.

7. RISK ANALYSIS

Risks can be defined as the effect of the uncertainty on pre-established objectives. Risks can be classified and evaluated under a specific methodology, considering the probability of occurrence of the risk and the effect of it in the scope proposed. The aim of risk management is to create a set of coordinated activities to direct and control an organization or a project regarding to risks (ISO 31000, 2009).

ISO 31000 standard defines a framework to assist organizations in establishing, operating, maintaining and continually improving their risk management.

The first step to limit the scope of risk management is to identify the risks and evaluate them. For each identified risk are established:

- The probability of its occurrence, defined as low, medium or high probability,

- The impact or critically of the occurrence, also defined as low, medium or high impact,

- The level of risk, defined by the combination of the probability and irt impact, according to the matrix showed in Figure 10,

- The action plan to be adopted in risk mitigation,

- The contingency plan, in case of failure of all actions.

The product of the correlation between probability and Impact must be framed into one of the regions of the matrix of risk classification. Green region indicates low levels risks, or, in other words, more acceptable risks. Medium risks (yellow region) must be evaluated in terms of cost-benefits of the mitigation measurements, while red region indicates risks, where some control measurements must be adopted.

First risk identified is regarding to the engagement of the teams, once every change tends to generate resistance. Along this work, this risk is correlated to the leadership role in organization, once the real effects actions are related to motivation, inspiration, clearance and, most of all, the active participation of all

involved. The lack of understanding and commitment of the team can affect the schedules or even the completion of the goals determined. This risk can be considered more likely to happen, once is common in every culture change process in any organization. The impact can be considered high, since the strength to compromise the objective of the project is significant.

The second risk identified refers to the political conjuncture of the company. Being part of local government brings to the scenario negotiations and concessions inherent to society's wills. In this context, is important to remark that nowadays, Metro-DF is under the prospection of concession of its services to private initiative. Once this risk is related to the nature of the company, is pretty coherent to consider its high occurrence. It is considered also of high impact, once is not possible to succeed in the objective without the acceptance of local government.

Third risk identified to certificate the company is regarding to technical issues. Once the control of activities is made upon a software and a database is possible that standardization of internal processes demands customizations of the software. This risk can be considered low in both probability and impact, since the system is designed to work in a quality managed plant and the tools to customize both interface and database are already available.
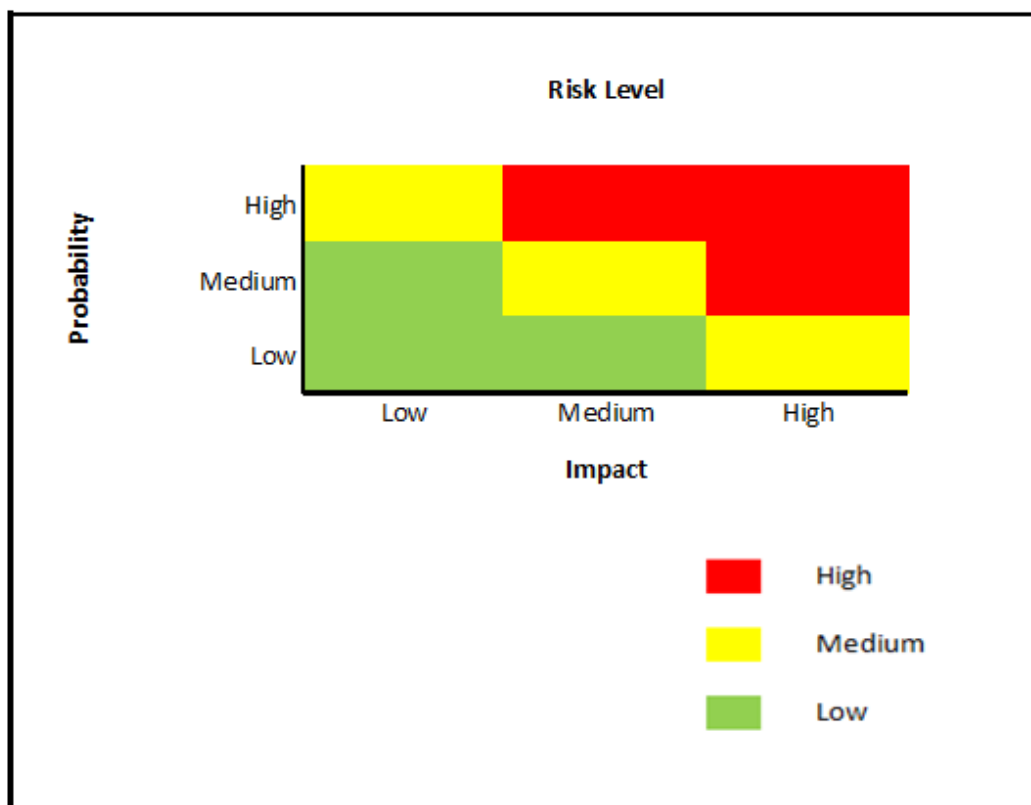
Figure 10 – Matrix of risk classification

Forth risk comes from the procedures to contract, which, as explained in previous sections of this work, is strongly limited by law. The probably of its occurrence is low, since this kind of contracting is very well documented and sourced. Although, its occurrence has several impacts to the objective, so the impact estimated is high.

All the risks identified were compiled in the risk matrix, as shown in Table 3. This matrix must be used as a guide during the implementation of the certification process, in order to keep the proper schedule and to foresee actions to fulfill the requirements.

Table 3. Risk Matrix

Risk	Description	Probability	Impact	Risk Level	Action Plan	Contingence Plan
1	Low engagement of the staff	High	High	High	Debate and get an uniform understanding of the project between the top management in order to chose the proper leaders to develop it.	Include consulting services in the scope of the contracting.
2	Low engagement of local government	Medium	High	High	Debate and get an uniform understanding of the project between the governmental agents in order to garantee the conditions to develop the project.	Put off the project.
3	Customization of the software	Low	Low	Low	Include in the intial team, technicians or Engineers with skills to evaluate and customize interfaces and database.	Contract a software development company to customize interfaces and databases,
4	Failure on public bidding	Low	High	Medium	Stablish a risk analisys regarding only to the bidding, contractor selection and a survey to keep the estimated costs in touch with the market.	Start a new public bidding process with correctioning the points that result in failure of the previous one.

During the concept phase and execution, the matrix must be revised, and each new risk found, updated. Since it is a continuous process, incremental improvements must be evaluated in every phase of the implementation.

8. PROJECT PLAN/IMPLEMENTATION PLAN

For the implementation of ISO 9001 in the rolling stock maintenance processes of METRÔ-DF, the schedule was proposed, according to Table xx, which consists of four phases.

The first phase is the preparation, where, initially, the descriptions of the activities of the areas involved are carried out, the clients of each process are identified and the assignments of each of the participants, having a medium term due to the collection of all this information. However, it should be noted that METRÔ-DF already has most of its processes documented in its technical collection.

Personnel teams are also selected to be part of the quality teams and internal auditors, in which it is recommended to be from different areas to which it is being certified, and also that the chosen people should have a spirit of leadership, interest, engagement and commitment to the work, in addition to a broad knowledge of the organization's operation, so as not to hinder the smooth running of the quality management project.

Still in this phase, there are sub steps referring to the preparation of the documentation (Term of Reference, Notice and budgeting) to carry out the bidding process. It is necessary to carry out studies and do market researches to prepare these documentation and, thus, obtain approval by the Company's Board of Executive Officers, as well as, subsequently, to initiate the bidding process and proceed with the hiring of the company to carry out: the training of the teams and the acquisition of the standard and certification of METRÔ-DF. This is the longest sub step of phase 1, and, as already informed, once METRÔ-DF is a public company, in order to contract, it has to comply with legal procedures, which are bureaucratic and have defined deadlines as well as rules foreseen in various legislation district and federal, in particular, its Internal Regulation for Bids and Contracts and the Law 13.303 / 2016, which provides for the legal status of public companies, among other entities.

After hiring the winning company, the training of the chosen teams is carried out and, then, the preparation of the development of the work for the formulation of the quality policy and its objectives begins. So, the Company and its teams will define objectives and results to be achieved.

Finally, still in phase 1, the METRÔ team checks if there are updates to any regulations or laws that can influence the certification work, namely: national or international technical standards, environmental legislation, legislation within the Federal District or the Union, manuals, among others.

In the second phase, which refers to the internal development of the works, the METRÔ teams will first assess and standardize the steps regarding the description of the processes and the formulation of quality policies, identifying any mistakes or difficulties, and then establish how the information flow will be in the implementation process.

The current situation is verified, through a check list, to identify if all the requirements have been met, and, thus, start the internal training of the other employees subjected to the Quality Management System, as well as participation in the internal workshops, sharing experiences and information among the participants.

At this point, all existing documentation that involves the maintenance processes of the Trains is listed. Example: Maintenance manuals, maintenance procedures, Service Orders, Specific Note Sheets, Material Requisitions, Maintenance Evaluation Report, Monthly Progress Report, Letters, Opinions, Field and Inspection Reports, among others, considering the updated versions.

In this second phase, a final review of the previous stages of this project must be made before its implementation, in order to avoid errors and make the necessary adjustments. Once this is done, all documentation that will serve as a basis for implementing the project in the next phase is consolidated.

Once all the internal discussion reaches its results, i.e., the parameters and requirements needed to fulfill the quality system, the third phase has all inputs for starting.

The implementation phase consist in develop the model proposed by ISO 9001, including the audits in the internal environment of the company. Once guaranteed that the certification is reachable, the external auditors shall report their analysis

First task on this phase consist in establish and define how the requirements and processes of previous phase will be assessed and evaluated as conformity.

Once the checklists for conformity are defined, the quality team review all the documentation prepared in the previous phase to submit it in formal templates. This include the draft of the quality manual, a document that comprises all the scope of the Quality System; explains all the requirements to be evaluated; presents the references for the procedures used in QMS; and details the interaction between the parts involved in the processes to be assessed and all the policies related to the QMS.

This manual is the guideline to achieve all the expectations of top management and customers of the areas in scope of QMS regarding quality. Also, it contains all the foundation required to achieve the compliance of the measurements assessed in the previous checklist.

Its approval must be followed by its wide dissemination within the organization's internal environment, ensuring that employees and other agents related to the QMS can commit themselves to fulfill the results expected. It is very important that the organization put effort in using all the internal communication tools available, avoiding restrict the access to the documentation only to a group of workers.

The subsequent task is to definitely implement the program at the areas subjected to the influence of the QMS. By this time, the risk related to motivation and engagement of the teams are more likely to be evident, resulting in a challenge for the organization, when it is needed to combine the enthusiasm with the sense of responsibility of the employees, ensuring that commitment goes along with engagement. The leadership role is the key to succeed this task.

The internal audit emulates the role of the certification agent, reason why the standard points towards some basic requirements (ISO 9001, 2015):

- As in any audit, ethical commitment must be the foundation in the conduction of this task, ensuring the reliability of its result.

- Although the impersonal character of the audit must be guaranteed, auditors must take into account the need to establish trust with the auditees. As explained in previous sections of this work, the human factor must have a place in this process.

- The independency of the auditors is also a value to be guaranteed, in order to avoid partial statements or incompletes results.

- All the findings and conclusions must be the most objective as possible. To fulfill the objectiveness, auditors must conduct all of its inspections in an evidence-based approach.

It is an important key to success that the auditors chosen had been part of the previous tasks under the project, as a signal of maturity regarding the QMS implementation.

The results of the internal audit must be critically reviewed, being a decision point to continue the project or make adjustments.

Once the results are satisfactory and disseminated to the involved, the organization is ready to start the last phase.

The final step to achieve the certification is to obtain a trusty report of an external certification agent.

It is expected that Metro-DF achieve this milestone of the project with a satisfactory result in internal audit, and with the implementation of all improvements suggested, once the result expected from the external audit is not likely to be distant from that obtained in previous task, if the internal audit had follow all the requirements of the standard.

The external audit comprises the analysis of documentation prepared by Metro-DF, according to its compliance with ISO 9001 standard, and the analysis of the processes that composes the scope of certification.

As the standard indicates, the length of the certification period is three years. After the certification process, described earlier, the company has to be prepared for the audits that occurs a year and two years after obtaining the certification.

These later audits have the objective to verify the maintenance of the conditions of certification and the development of the improvements proposed.

Finished the three years period, all the tasks must be replicated for a new triennial of planning, review and development to obtain ISO certification once more, keeping the Quality Management Certification as a cyclic and incremental process inside the company.

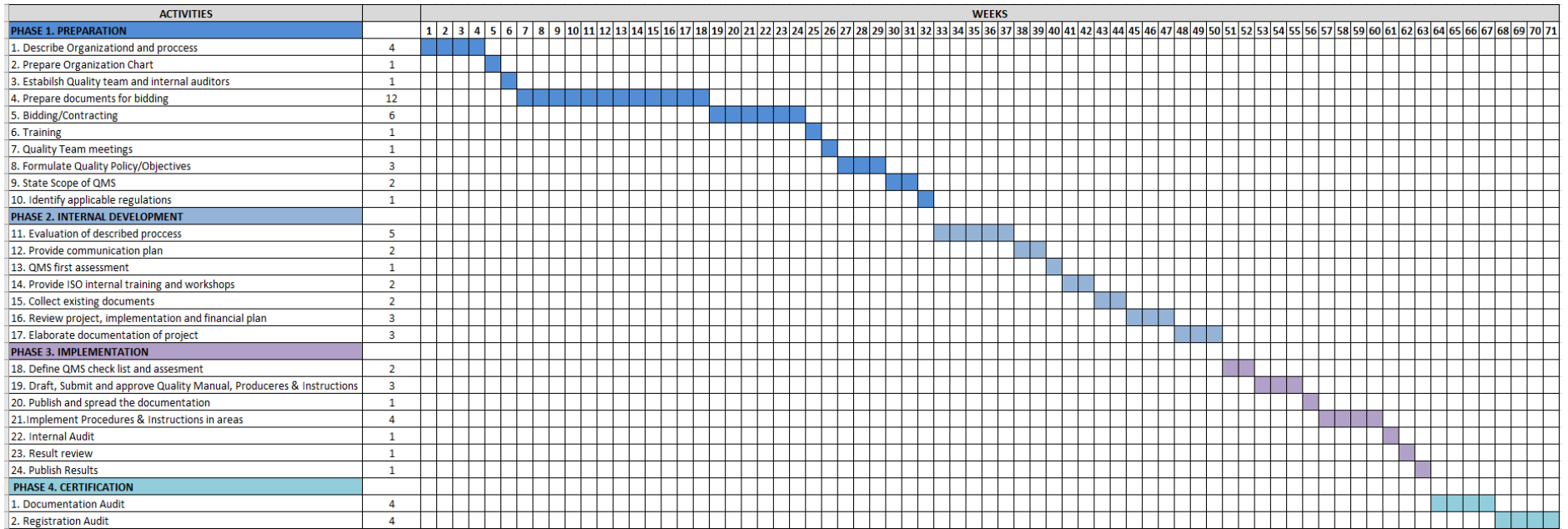| ACTIVITIES		WEEKS
PHASE 1. PREPARATION		1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71
1. Describe Organizationd and proccess	4	
2. Prepare Organization Chart	1	
3. Estabilsh Quality team and internal auditors	1	
4. Prepare documents for bidding	12	
5. Bidding/Contracting	6	
6. Training	1	
7. Quality Team meetings	1	
8. Formulate Quality Policy/Objectives	3	
9. State Scope of QMS	2	
10. Identify applicable regulations	1	
PHASE 2. INTERNAL DEVELOPMENT		
11. Evaluation of described proccess	5	
12. Provide communication plan	2	
13. QMS first assessment	1	
14. Provide ISO internal training and workshops	2	
15. Collect existing documents	2	
16. Review project, implementation and financial plan	3	
17. Elaborate documentation of project	3	
PHASE 3. IMPLEMENTATION		
18. Define QMS check list and assesment	2	
19. Draft, Submit and approve Quality Manual, Produceres & Instructions	3	
20. Publish and spread the documentation	1	
21.Implement Procedures & Instructions in areas	4	
22. Internal Audit	1	
23. Result review	1	
24. Publish Results	1	
PHASE 4. CERTIFICATION		
1. Documentation Audit	4	
2. Registration Audit	4	

Figure 11 – ISO implementation schedule

9. FINANCIAL PLAN

As could be seen previously in section 6, at first certification comprehended the three first years of the project, is possible to have a project return at 4th year in a perspective of 5 years project effects. Therefore, is reasonable to think that the certification will continue for many years, and to evaluate the financial performance of the project we could consider for a financial plan for a period of two certifications, or six years of project.

A financial plan is a process a company lays out for utilizing its available capital and other assets to meet its goals for growth or profit based on a reasonable financial forecast. A financial plan can be considered synonymous with a business plan in that it lays out what a company plans to do in terms of putting resources to work to generate maximum possible revenues.

As a Financial Plan of costs with Rolling Stock certification is assumed that the expenses will decrease for the next three years after the first certification, which means a growth in cash flow because penalty continuously decrease every year (meaning positive inflows in cash as assumed).

The assumption that the decrease in penalty values as main proxy cash in variable is used, and the same discount rate adopted of 5,2% per year. The use of a progressive reduction on penalty values is aligned with the assumption of a discount in contract of maintenance of rolling stock, is reasonable to say that without ISO based management of maintenance the risk is bigger and costs will be influenced by that risks, therefore the opposite also occurs.

In Table 4 is presented the worksheet of costs/year in a six-year horizon of the project and as mentioned the decrease of expenses accounted yearly after the third year of project.

It's possible to obtain a cash flow of project taking in account penalty reductions as seen more ahead in figure xxx with a graph and sheet representation of that cash flow as Net Present Values which means a financial forecast. That's needed to effectively manage working capital and cash flow, a company must have a reasonable idea of how much revenue it plans to receive over a given time period and what its necessary expenses will be over that same period.

Table 4. Financial Plan

Costs/ Year						
1 - Taxes	**1st Year**	**2nd Year**	**3rd Year**	**4th Year**	**5th Year**	**6th Year**
Registration License use trademark INMETRO[1]	R$ 1.352,74	R$ -	R$ -	R$ -	R$ -	R$ -
Original copies of the License Registration use of the INMETRO trademark	R$ 2.067,00	R$ -	R$ -	R$ -	R$ -	R$ -
Partial total Taxes	**R$ 3.419,74**	**R$ -**	**R$ -**	**R$ -**	**R$ -**	**R$ -**
2 - Audits						
Document analysis	R$ 70.342,48	R$ 70.342,48	R$ 63.578,78	R$ -	R$ -	R$ -
Initial Audit	R$ 2.705,48	R$ -	R$ -	R$ 2.705,48	R$ -	R$ -
Audit Certification Areas (1 year)	R$ 22.996,58	R$ -	R$ -	R$ 22.996,58	R$ -	R$ -
Audit Maintenance / Monitoring Areas (2nd, 3rd, 4th, 5th year)	R$ -	R$ 20.291,10	R$ 20.291,10	R$ 20.291,10	R$ 18.938,36	
Follow-up audit (certifier's office)	R$ -	R$ 2.705,48	R$ 2.705,48	R$ -	R$ 2.705,48	R$ 2.705,48
Partial total Audits	**R$ 96.044,54**	**R$ 93.339,06**	**R$ 86.575,36**	**R$ 45.993,16**	**R$ 21.643,84**	**R$ 2.705,48**
3 - Other expenses						
Travel and training expenses	R$ 21.643,84	R$ 18.938,36	R$ 16.232,88	R$ 16.232,88	R$ 16.232,88	R$ 16.232,88
Total / Year	**R$ 121.108,12**	**R$ 112.277,42**	**R$ 102.808,24**	**R$ 62.226,04**	**R$ 37.876,72**	**R$ 18.938,36**
GRAND TOTAL						**R$ 455.234,90**

To do a good evaluation of the financial performance of the project, it is needed to pick the values in the same basis, and to acquire that is used the Net Present Value that puts all values in the present with a discount rate as could be seen in the equation 3.

$$NPV = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t} \qquad (3)$$

Where:

R_t = Net cash inflow-outflows during a single period t

i = Discount rate or return that could be earned in alternative investments

t = Number of time periods

A positive Net Present Value indicates that the projected earnings generated by a project or investment exceeds the anticipated costs. It is assumed that an investment with a positive NPV will be profitable, and an investment with a negative NPV will result in a net loss. This concept is the basis for the Net Present Value Rule, which dictates that only investments with positive NPV values should be considered.

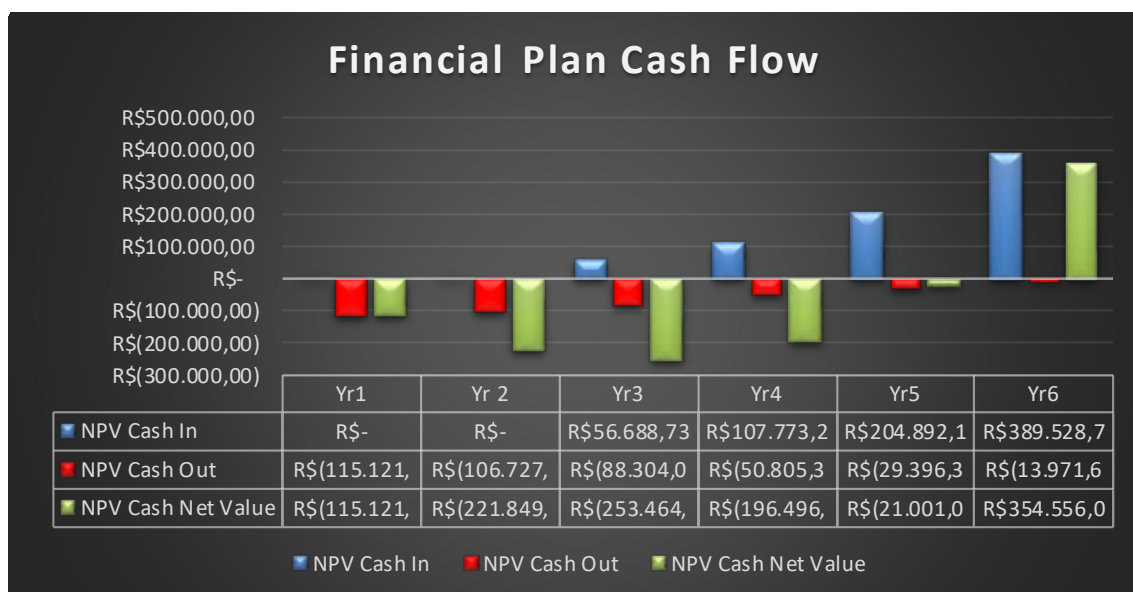|	Yr1	Yr 2	Yr3	Yr4	Yr5	Yr6
NPV Cash In	R$-	R$-	R$56.688,73	R$107.773,2	R$204.892,1	R$389.528,7
NPV Cash Out	R$(115.121,	R$(106.727,	R$(88.304,0	R$(50.805,3	R$(29.396,3	R$(13.971,6
NPV Cash Net Value	R$(115.121,	R$(221.849,	R$(253.464,	R$(196.496,	R$(21.001,0	R$354.556,0

Figure 12 – NPV of Financial Plan Cash Flow

As seen in section 6, after five years the NPV of the project was positive, here, as taking in consideration the cash flow from a financial plan for six years as presented in the graph and table down in Figure 12, the Net cash inflow-outflow after the time periods will be positive in R$ 354.556,02.

Taking in account the assumption that the penalty reduction results in reduction of contract costs, is possible to acquire a payback period of 3,2 years. The payback period refers to the amount of time it takes to recover the cost of an investment or how long it takes for an investor to reach breakeven.

The payback period is the cost of the investment divided by the annual cash flow. The shorter the payback period, the more desirable the investment. As we could see, a six-year investment in Rolling Stock ISO9001 certification results in a short period of 3,2 year to generate return, it indicates that investment is feasible.

Most managers and executives like methods that look at a company's capital budgeting and performance. They tend to prefer using IRR or the internal rate of return instead of the NPV or net present value. But using IRR alone may not produce the most desirable results.

The internal rate of return is a metric used in financial analysis to estimate the profitability of potential investments. The internal rate of return is a discount rate that makes the net present value (NPV) of all cash flows equal to zero in a discounted cash flow analysis. IRR calculations rely on the same formula as NPV does as seen in equation 4.

$$0 = \sum_{t=1}^{T} \frac{C_t}{(1 + IRR)^t} - C_0 \qquad (4)$$

where:

C_t = Net cash inflow during the period t

C_0 = Total initial investment costs

IRR = The internal rate of return

t = Number of time periods

The current project has a high IRR of 25,49% that overpasses many times the current discount tax estimated in 5,2%. That high IRR rate means that project can go ahead, and it assumed thar could grow more over the time as the failures in maintenance procedures in rolling stock will reduces as quality grows following a continuous improvement with the ISO9001 certification process.

Is possible to infer that both IRR and NPV can be used to determine how desirable the project will be and whether it will add value to the company. Use of IRR alone as a measure of capital budgeting, it does come with problems because it doesn't consider changing factors such as different discount rates. In these cases, using the net present value would be more beneficial.

CONCLUSION

Considering the maintenance activities in Rolling Stock and its importance for the METRÔ-DF Operation, this organization gather all conditions that makes viable the implantation of a Quality Management System and the certification under the ISO 9001 standard.

The implementation plan proposed consider the challenges and advantages that the organization have due its nature, as a provider of public services in passenger transport.

The advantages are mainly referred to the safety-related procedures and quality in the execution of services, that are common at passenger companies, such rail operators or flying companies. The specifical design of the components involved in systems that compose a train usually demands very rigid procedures, that require maintenance interventions with high reliability and, if possible, avoiding waste of resources.

The project obtained numbers that represent good performance through the possibility of cost reduction through the certification and implementation of a QMS, such reductions could be due to future hiring of maintenance services by reducing risks through increasing quality. The B / C result for a first three-year certification cycle justifies the adoption of an ISO9001 certification.

Considering the continuity of the certification, the project's financial indicators for the Rolling Stock area lead us to believe that all other areas of the company would benefit as they also obtain ISO9001 certification. It is important to highlight that a communication process with METRÔ-DF customers about obtaining certification is extremely important, which can reflect positively on the company's earnings.

The challenges come mostly from the public nature of the company, the compromise of transparency and multi-level approvals of decisions, costing, in a market point of view, agility and increasing bureaucracy for processes that involves contracting. As it is a public company, all phases of preparation of the bidding as well as carrying out the bidding for contracting a company with a view to certification may require compliance with several procedures and deadlines defined in legislation, which makes the process longer when compared to the private entity, which can make a contract immediately.

The proposal in this work comprises a short-term of three years, describing the steps to achieve certification in 71 weeks, almost a year and half, expecting gains in both financial, by reducing waste, and in service, allowing increases in

maintenance performance indexes, and consequently, in the availability of rolling stock as well as the safety and quality of services provided to the population of the Federal District. In addition, METRÔ-DF will become an ISO certified organization, becoming a reference for other public companies at the local level and for other subways.

REFERENCES

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS (ABNT). História da normalização brasileira. 2011.

_____. ABNT NBR ISO9001:2008: Sistemas de gestão da qualidade - requisitos. Rio de Janeiro, 2008.

_____. ABNT NBR ISO 9001:2015. Sistemas de gestão da qualidade – Requisi-tos. Rio de Janeiro, 2015.

CARPINETTI, L.C.Ribeiro. Gestão da qualidade: conceitos e técnicas. 2.ed. São Paulo: Atlas, 2012.

CARVALHO, Marly Monteiro de; PALADINI, Edson Pacheco (Coordenadores). Gestão da qualidade. 2.ed. Rio de Janeiro: Elsevier:Abepro, 2012.

CASADESÚS, M.; GIMÉNEZ, G.; HERAS, I. Benefits of ISO 9000 implementation in Spanish industry. European Business Review, V. 13, N. 6, P. 327-35, 2001.

_____. CCR Metrô Bahia. Sistema de Gestão Integrada. Available at <http://www.ccrmetrobahia.com.br/institucional/sistema-de-gest%C3%A3o-integrada/>. Accessed in 10/31/2020.

CHEQUETTI, Edvaldo. ViaQuatro conquista certificação ISO 9001. Available at <http://www.viaquatro.com.br/imprensa/noticias/viaquatro-conquista-certificacao-iso-9001?releaseid=11534>. Accessed in 10/31/2020.

_____. CPTM, Sistema de gestão de qualidade. Available at <https://www.cptm.sp.gov.br/seguranca/Pages/sitema_de_gestao_da_qualidade.aspx>. Accessed in 10/31/2020.

_____.DEPARTAMENTO DE IMPRENSA DO METRÔ, Premiação: Metrô recebe certificação ISO 9001. Available at <https://www.saopaulo.sp.gov.br/eventos/premiacao-metro-recebe-certificacao-iso-9001/>. Accessed in 10/31/2020.

_____. ENGECOMPANY, HOME. Available at <https://engeman.com.br/pt-br/o-que-e-o-engeman/>. Accessed in 10/21/2020.

FOGLIATTO, Flávio Sanson; RIBEIRO, José Luis Duarte. Confiabilidade e Manutenção Industrial. 7 ed. São Paulo, Elsevier, 2009.

JASKYTE, Kristina. Transformational Leadership, Organizational Culture, and Innovativeness in Nonprofit Organizations, Wilwey Periodicals, 2004. Available at <https://onlinelibrary.wiley.com/doi/abs/10.1002/nml.59>. Accessed in 10/29/2020.

JURAN, J.M. Juran´s quality control handbook. 4th.ed. Singapore: McGraw-Hill Book Co., 1988.

LOURENÇO FILHO, Rui de C.B. Controle estatístico de qualidade. Rio de Janeiro: Livros Técnicos e Científicos, 1980.

_____. METRÔ-DF, ESTRUTURA. Available at <http://www.metro.df.gov.br/?page_id=4850>. Accessed in 10/21/2020.

_____. METRÔRIO, HISTÓRIA. Available at <https://www.metrorio.com.br/Empresa/Historia?p_interna=3>. Accessed in 10/31/2020.

SOLOMON, Brian. Railroad Signaling, 1st ed. Voyager Press, 2010.

_____. TEMPLUM Consultoria. ISO 9001. Available at <https://certificacaoiso.com.br/iso-9001/>. Accessed in 10/21/2020.