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**HOW TO INCREASE OPERATIONAL CAPACITY AND MAKE THE BUSINESS
MORE PROFITABLE:
THE DECISION TO INVEST IN CONCRETE SLEEPERS VERSUS CONTINUE
WITH WOODEN SLEEPERS.**

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Project presented to the Deutsche Bahn Rail Academy as a final requirement for completion of the Rail Transportation Management Course.

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We dedicate this project to our families, for the education and affection they gave us and that allowed us to be better people; to our classmates, for the partnership and joy that transformed our learning environment; our teachers, for the opportunity to share experiences and exchange knowledge; and to the cargo transportation sector in Brazil.

“What cannot be measured, cannot be managed.”

(William Edwards Deming)

“Only through knowledge can we simplify things”.

(Unknown Author)

ABSTRACT

The maximum use of invested capital is a quest that, in addition to offering greater returns to shareholders in the rail freight sector, also translates into better customer service.

Evaluating alternatives that make it possible to increase the operational capacity of a company in an industry that demands high investments is always a very important task, since any evaluation error can lead to a wrong decision and not always lead to the desired results.

The permanent way maintenance area in a rail freight transport company is of major importance, especially in a concession model where the responsibility for the infrastructure belongs to the concessionaire.

Constant investments in its maintenance and modernization are necessary to achieve the objective of making the most of the availability of the track, offer greater security, reliability in the services of delivery of the loads that are translated in punctuality.

The present work aimed to bring the maintenance area to focus and through the analysis of the current situation, comparative investments and potential returns, offer reliable information for decision making that aims to increase the operational capacity of FTL (Ferrovía Transnordestina Logística S/A).

LIST OF FIGURES

Figure 1 – FTL Map. Page 13

LIST OF TABLES AND GRAPHICS

Table 1 - Deming's 14 Point Philosophy	Page 16
Table 2 - Current Operational Indicator.....	Page 26
Table 3 - Current Fuel	Page 26
Table 4 - Future Operational Indicators post wooden sleepers modernization	Page 27
Table 5 - Future Operational Indicators post concrete sleepers modernization.....	Page 29
Table 6 - Comparative Operational Indicators Wooden x Concrete.....	Page 30
Table 7 - Comparative Investment analysis Wooden x Concrete.....	Page 30
Table 8 - Results and variation of the comparison.....	Page 30
Table 9 - Cash flow of the variation.....	Page 31
Table 10 - Cash flow of the total project for concrete sleeper modernization.....	Page 31

LIST OF ABBREVIATIONS AND ACRONYMS

NGO	Nonprofit Organization.
KPI	Key Performance Indicator.
IT	Information Technology
FTL	Ferrovía Transnordestina Logística S/A
ISO	International Standardization Organization
NPV	Net Present Value
IRR	Internal Rate of Return
IRRM	Internal Rate of Return Modified
MAR	Minimum Attraction Rate
ANTT	Nacional Terrestrial Transportation Agency
GTK	Gross Tonne per kilometer

SUMMARY

1.	PREAMBLE	Page 10
	1.1.Problem Formulation	Page 10
	1.2.Justification	Page 11
	1.3.Objectives	Page 11
	1.4.Presentation	Page 11
2.	RESEARCH METHODOLOGY	Page 12
3.	ABOUT THE COMPANY	Page 12
	3.1.Overview	Page 12
	3.2.Synthesis of Perceptions and Facts	Page 13
4.	CONCEPTUAL BASES	Page 14
	4.1.Process Improvements	Page 14
	4.2.Organizational Synchronism	Page 17
	4.3.Economic viability analysis of investments.....	Page 21
5.	SOLUTION PROPOSAL	Page 25
	5.1. Current situation	Page 25
	5.2. Solution 1 – Wooden Sleepers	Page 26
	5.3. Solution 2 – Concrete Sleepers.....	Page 28
	5.4. Comparative Summary Table: Wood vs. Concrete.....	Page 30
6.	CONCLUSIONS AND RECOMMENDATIONS.....	Page 32
7.	BIBLIOGRAPHIC REFERENCE.....	Page 33

1 PREAMBLE

As in many businesses, the maximum use of assets is translated into productivity and is directly related to the possibility of generating results. In the segment of railroad cargo transportation, focusing on the permanent way in general, what is sought is to keep as much as possible available for operation and with the possibility of trains operating at maximum speed without compromising safety. This allows an operation with greater productivity, security, quality service offering, allowing a higher revenue capture, it is expected that the operation is the most economical possible to obtain a greater profitability on the capital employed.

Graciano (1971) says that transporting people, goods and information is very important for the growth of a nation and that the faster, safer and cheaper the circulation, the greater the chances of a country emerging in the world economic scenario.

Effective transport and fleet management requires knowledge, qualification and continuous updating to work at ever lower costs without compromising the quality of operation result, and consequently the safety and operator, user and customer satisfaction.

Quality and productivity forms the basis for increased efficiency, also in transport management. For companies, this will lead to profitability and competitiveness, contributing to their sustainable growth.

For this efficient and effective administration, it is essential to establish a systemic organizational structure that thinks and makes decisions with maximum strategic alignment.

Most of the strategic decisions of permanent maintenance management have as analysis points the problem of the volume of financial resources required, the materials employed, the level of interruption of the track to perform the services and the operational improvements that will follow the investments. In this sense, the research object of this work maintains its central focus in the application of investment analysis methodologies to perform a feedback evaluation between two types of materials, wood sleepers and concrete sleepers.

1.1 Problem Formulation

According to researches with companies in the rail transportation segment, maintenance costs of the permanent way, including personnel, materials and costs with accidents, are the most relevant operational costs, considering the current concession models in Brazil.

In addition, the reduction of operational capacity caused mainly by the permanent way downtime, to carry out maintenance, whether preventive or corrective, and the restrictions of speeds imposed due to some type of inadequate condition are the main reasons for loss of productivity and loss of revenues of Brazilian railway companies.

This finding presents a problem that points to the need for improvement and modernization of railroads, especially those where conditions are precarious, also focusing on the decision on which materials can present a better investment versus return relationship.

1.2 Justification

Due to the relevance of the permanent way to a rail freight transportation company, either because of the high volume of financial resources involved, because of its unavailability and the impacts on revenue decrease, as well as factors related to operational safety, it is extremely necessary going deeper on this subject.

1.3 Objectives

Considering the needs of FTL to seek modernization in its permanent way to comply with the legislation of dangerous products and to be a company with greater profitability, the present study intends to offer a deeper analysis on the investments and benefits related to which type of sleeper to use.

1.4 Presentation

The methodology used for the development of this research will be presented, including the strategy, the method and the instrument used to collect the data.

In chapter 3, a brief presentation of the current situation of the company will be made for the proposed theme.

In chapter 4, the conceptual bases on which this study will be developed will be presented. The subject will be the economic feasibility analysis for the proposed investments.

In Chapter 5, the proposed solution will be presented highlighting the conclusion of this project.

2 RESEARCH METHODOLOGY

This final work based its research and study on the exploratory method, that is, a survey of the best practices used for investment analysis.

The method used was the reference of the materials and learning of the course "Rail Transportation Management", besides books destined to the financial management and maintenance of permanent way.

Data collection included a survey of information and direct interviews with FTL managers, as well as data on operational, commercial and providers KPI.

The strategy for the development of this work used both quantitative and qualitative methods. The quantitative aspects were used as parameters for the necessary correlations between the data, since we will analyze how the implementation of the modernizations can impact the operational capacity and the respective potential of revenues generation, in addition, also the economic potential will be considered through of cost reduction.

Regarding the qualitative aspects, it was necessary due to the specificity of the topic studied in this final work, from the parameters used to perform the correlation and generate the main indicators (KPI) to the very characteristic of the FTL operation.

3 ABOUT THE COMPANY

3.1 Overview

FTL (Ferrovia Transnordestina Logística S/A) is a freight railroad company operating in the Northeast of Brazil. It has been a public transportation service concessionaire since 1998, when there were privatizations of this sector in Brazil.

With a rail line of 4.238 kilometers, of which 1.237 are operational (figure 1), the company transports approximately 3 million tons of cargo annually, such as: fuels, cellulose, cement, steel, among others of lesser importance.

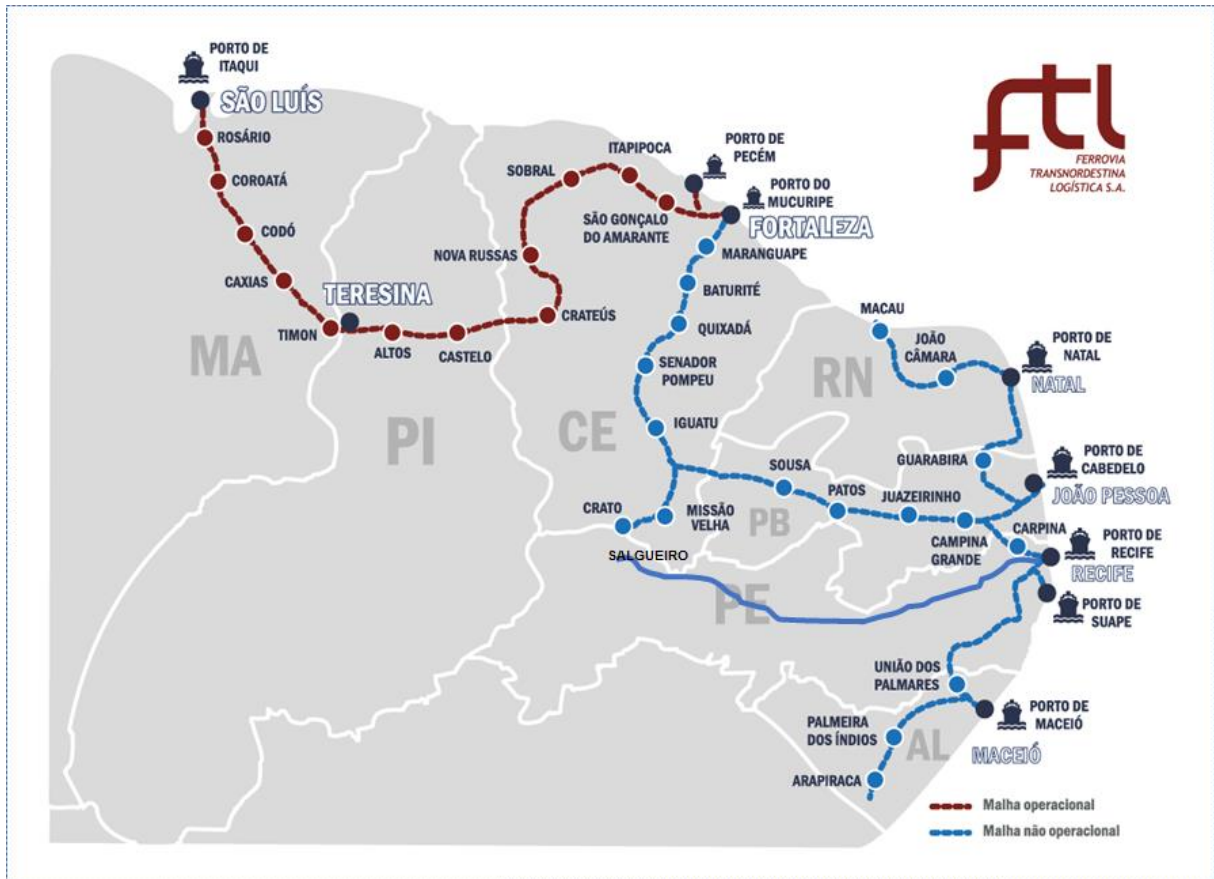


Figure 1 – FTL Map.

3.2 Synthesis of Perceptions and Facts

Currently, FTL uses only 1.237 kilometers of rail line to provide its transportation freight services, all of them with wood sleepers. The present study focused only on the part of railroad between the cities of São Luís (MA) and Teresina (PI), which corresponds to 492 kilometers of track. This is the rail line where the company mainly carries fuels.

This part of the railroad has a high level of degradation and, this scenario imposes, among other things, a series of speed restrictions, which reduce the productivity of the operations, reduce their transportation capacity and, consequently, affect the profitability of the business.

In this context, the company decided to carry out a major modernization of its permanent way in this part and it is in this scenario that we intend to evaluate and choose which type of sleeper is most suitable for this modernization.

4. CONCEPTUAL BASES

With the purpose of seeking support for the objectives of this work, we summarize in this chapter the research carried out on the topics that will be discussed below:

- Process Improvement and Organizational Synchronism, with the objective of ensuring a correct vision of what really matters for the organization and especially the strategic alignment of the decisions. It is important to remember that even before the economic and financial analysis for the selection, the decision on the modernization of the part of railroad was fundamental, understanding the priority processes of the company and how to involve the whole organization in a significant change in the permanent way.
- Economic financial analysis of investments - core theme of the present work.

4.1 Process Improvements

We can't speak in process without mentioning the history of administration. To better explain what processes are in an organization and its origin, it is important to remember the division of labor and the father of scientific management, Frederick Taylor.

Using his training and experience as an engineer, Taylor tried to improve the activities on the assembly line, in order to make the organizational routine more efficient. As a result, it sought to make the best use of resources in the shortest possible time, in order to reduce costs and increase the organization's profit.

As society and the organizational environment moved from the countryside to the city, becoming more industrial, Taylor sought to spread the idea of more standardized work, creating the Rational Work Design, aiming to "replace traditional systems by bureaucratic structures that guarantee the functionality and efficiency of the productive process". (ARAÚJO, 2006).

Seeking the standardization and quality of the productive process, Taylor took the first steps in the idea of determining the organizational processes, in order to make the company more efficient and competitive.

It is important to remember that when speaking of Taylor, we speak of an era and of a society that went through a post-industrial revolution period. Today, with globalization, the internet and knowledge passing almost expressively, the situation is more complex.

According to Araújo, Garcia and Martines (2011, p.18):

Difícil encontrar pessoas que adquiram produtos sem uma pesquisa breve em sites de diversas organizações [...], assim, as organizações não só passaram a ter que trabalhar com concorrentes, como também com clientes altamente exigentes e cada vez mais conscientes do seu poder nesta relação.

[Free Translation]

It is difficult to find people who buy products without a brief survey on websites of various organizations [...], for all that, organizations not only have to work with competitors, but also with highly demanding customers and much more aware of their power in this relationship.

Every company is made up of its human capital, its technology and its processes, in order to execute its purpose as an organization.

"In today's world of customers, competition, and change, task-oriented activities are obsolete. Instead, companies need to organize their work around processes".

(HAMMER, 1994).

The processes of a company are of high importance for the execution of their day to day work and must be present from small and medium companies, as in large companies, as well as in NGO and any other type of business organization.

An organization must be understood as a great organism, being an integrated system among all the sectors, people and activities, directed to the final objective, be it a service or a product. Organizational processes dictate all the activities of the organization, and each end of a process is the beginning of the other one, until it reaches its end: the final consumer.

All companies use processes, which are standardized - when they are properly studied and planned - or non-standardized, when they occur as a consequence of the day-to-day work of the organization.

It is important that processes add value to each part of themselves, so that their output (process end) is more important than their input (process start).

With modern globalized society, customers are demanding much more in relation to the final product or service. It is possible to affirm that organizations suffer extreme pressure from their clients regarding the quality of their operation and products. When talking about quality, we cannot forget about the work of “*Joseph Juran*”, and his contribution for the PDCA (Plan, Execute, Control and Act) cycle, as well as the work of William Demming, with 14 Point Philosophy, presented in the Table 1, below.

Table 1 - Deming's 14 Point Philosophy

1	Create a constant purpose toward improvement;
2	Adopt the new philosophy;
3	Stop depending on inspections;
4	Use a single supplier for any one item;
5	Improve constantly and forever;
6	Use training on the job;
7	Implement leadership;
8	Eliminate fear;
9	Break down barriers between departments;
10	Get rid of unclear slogans;
11	Eliminate management by objectives;
12	Remove barriers to pride of workmanship;
13	Implement education and self-improvement;
14	Make "transformation" everyone's job.

Source: DEMING, 1990.

Therefore, in order to remain competitive in a globalized world, it is essential that the company be efficient with its resources, and for this, it is necessary that the processes are well designed.

According to *Davenport (2004)*, processes are a "specific ordering of work activities in time and space, with a beginning and an end, with clearly identified inputs and outputs".

In this way, we understand that process is a union of activities that follow a sequence, divided by stages, each with its own tasks. In the hierarchy of processes, we can have a macro-process that is divided into several sub-processes, which together, are related to perform a given activity.

The processes of an organization must help the day to day work, not only guiding the routine of its employees, but also to assist the decision-making process of the strategic board, as well as of the whole hierarchical pyramid of the company.

An interesting way out for organizations that are looking to reinvent themselves is the technique called "*Process Reengineering*". The term reengineering was inserted by Michael Hammer, and consists of reinventing the main procedures used in an organization.

According to Hammer (1998),

Reengenharia é o repensar fundamental e a reestruturação radical dos processos empresariais que visam alcançar drásticas melhorias em indicadores críticos e contemporâneos de desempenho, tais como custos, qualidade, atendimento e velocidade.

[Free Translation]

Reengineering is the fundamental rethinking and radical restructuring of business processes that aim to achieve dramatic improvements in critical and contemporary performance indicators such as cost, quality, service and speed.

The process of reengineering seeks to modify the way of an organization, impacting on the routine of work in order to be a more competitive company. Basically, this process is divided into four stages: Preparation, Planning, Implementation and Evaluation.

The first stage, Preparation, consists of studying all the existing processes in the organization, defining those that will need to be changed, as well as giving feasibility to the necessary changes.

In the second stage, Planning, the organization needs to ensure the resources that will be needed for the change and also assemble the teams and their assignments.

Already in the third stage, Implementation, the organization must highlight the selected processes, reinventing them.

Finally, in the last step, Evaluation, we measure the impact of the changes made and studied the effects of the changes in the organization.

To improve its processes, the company must eliminate bottlenecks, which are the points that stop or slow down the process.

Even if intangible, organizations should be aware of their work environment, creating a harmonious place to work, where employees respect and feel valued, is key to the company's processes being executed with excellence.

4.2 Organizational Synchronism

It is necessary to ensure alignment between strategies, processes and people, which, let's face it, is not an easy task. Through various tools and theories that will help us think and act, the company needs to develop in your team this new alignment of thought and action.

Over time, we find the following list of most obvious concerns that bother organizations and their managers: costs, survival, people, productivity, billing, lack of payment problems, customers, processes, market, technology, competition, ethics and environment.

Reflecting on this list, the first fact is that the concerns are "common", varying only in intensity and or order of relative importance, and very little in essence, or according to the type of organization, in the size, origin of the resources and region.

A second confirmation is that, in addition to being common, these concerns are "classic", which means that they have long been part of the daily lives of people, managers and companies and are already part of the routine, and are therefore regarded as normal.

The third finding is that in search of a harmonious coexistence for all involved and trying to demonstrate that companies are not stopped, for every common and classic concern, "remedies" are administered. As concerns, the remedies are also common and classic, increasing only the dose administered, until the concern becomes chronic.

Another feature of these common and classic remedies is that they are harmless or in most situations act specifically on pain and not on disease.

There are many projects underway in the companies from the perspective of specific disciplines and specialties: waste reduction programs, loyalty project, remuneration program, total quality, ISO certifications, etc. However, thought separately, each effort is justified, because it runs on its own and few if any of them is a result of the whole.

Using the latest in information technology (IT) and management, and taking care to respect the cultural characteristics of the organization, these three organizational components can and should be redesigned in an integrated way.

This alignment is only possible with the definition of a few relevant and common management indicators (KPI), that together represent the market view and the needs of the business. There is no point in a clear strategy if the critical business processes, which are justly critical for their relevance in deploying the strategy, going in another direction. It would also not help to have a strategy aligned with the processes if people continue to think and act in the conventional and historical way.

In conclusion, the definition and implementation of these indicators have been the way in which companies can guide the mind and actions of managers of the various functions that make up the organizational context and the management of internal and external relationships (clients, suppliers, competitors, environment) organization. This is what we consider and think is necessary to achieve organizational synchronism.

Next, we'll detail how to deploy organizational synchronism.

The implementation of Organizational Synchronism begins with the awareness of the company board. The next step is the definition of the strategy, that is, the definition of the "North" where the organization wants to go and how long, if managers have not yet defined it.

With the strategies defined and traced, a list of all the processes of the organization is made, selecting the critical processes (so called because they are the ones that most lever the strategies previously traced). To work on these critical processes and synchronize them with

the organization's strategy, the work teams begin to be assembled according to the concept of "Ideal Team". This team is formed with key people from each area through which the process passes, as well as a member of the Human Resources area and another member of the Information Technology area.

With the Ideal team assembled and trained, processes are redesigned, not only to make them more agile, but mainly, to make them synchronized with corporate strategies, generating sustainable competitive advantages.

This implementation model guarantees a high level of commitment of the employees with the redesigned processes, since, in most cases, the implanted solutions come from the team itself.

With people and new processes implemented, both aligned with strategy, business management is done through performance indicators and a measurement system. With this system, we can measure the performance of the process and not the performance of an area, department or person, separately. In this way, employees are evaluated, also for their contribution and generation of value and alignment with the rest of the organization.

Most of the difficulties within the companies happen not because of the bad will of the people, but because of the lack of synchronism and alignment between the actions and the strategy of the organization.

By everything that has already been placed, how to implement the policy of integrating the strategy indicators, processes and people?

We must keep the teams and the organization in line with the strategy and focus on what is relevant. Thus, we must seek at all times relevant indicators that can help us organize finances, research and development, human resources and other sectors with effective and harmonic processes.

In the second moment, we will use a process to unite the strategies to the people, using the related performance indicators through the creation of a measurement system and finally, we will guide people to create a technical standard of work, seeking to know their skills, standards, capacity, items for measurements and resources, among other inputs inherent to people.

In this model, the synchronism seeks to direct the company to the client and guarantee the quality of the processes, without giving up the agility. The implementation of the horizontal management system proposes to do better and with more agility, treating them as a value chain, adapting them to market contingencies and providing customer value. Horizontal systems not

only improve the speed of response to the market and the company's ability to provide custom mass products, but also increase the efficiency and effectiveness of the macro processes.

In performance indicators, it is essential to take into account the point of view of the organization (internal) and the clients (external). In this way, we consider the following assumptions as vital in the implementation of synchronism:

- a) Speed and Focus: it is not enough to walk slowly but safely, and not to run without a goal. Speed only makes sense if you're headed in the right direction. When everything is under control, it is a sign that we are not going fast enough. When the pace of change within the enterprise is exceeded by the pace of change outside it, the end is near;
- b) Changes: Voluntary x Forced;
- c) Ideas: Attachment to the old x Innovations;
- d) Vision: Present x Future;
- e) Flexibility and Innovation: the market has an evolutionary spiral of needs (disruption), and the company must have competitiveness to follow these evolutions;
- f) Do more with fewer resources: seek all the resources already available in the organization and that will not imply more costs and, when these are not available, go search the market, always keeping the caution of having more paying less;
- g) Power for the People: decentralize the decision making process, making the individual able to change the route of a process if it is running away from the business logic of the company;
- h) Learning and focus on people: so that they can have training and retention of the knowledge necessary for the good performance of the processes.

Today, with the easy of seeking information on the internet, once globalization is a reality, people each day are discovering new ways to share relevant knowledge with great speed. As a consequence, markets are getting better prepared, with more speed and ability to identify the best options to meet the needs of customers.

4.3 Economic viability analysis of investments

Conducting a good economic and financial feasibility study of an investment project requires knowledge of some essential concepts and the application of analytical methods. Among these concepts are: cash flow, economical engineering methods and sensitivity analysis - which takes into account different scenarios that may occur.

a) On the economic and financial feasibility study

The economic and financial feasibility study of an investment project consists of an analysis process for the strategic level of an organization that will investigate which projects are interesting that the company executes and which ones should be rejected.

Casarotto (2016, p. 65) suggests that an economic feasibility study follow a plan, which the author calls a "pre-project", and defines it as:

“[...] stage of a business enterprise consisting of a set of parameter definitions necessary for the design of engineering projects - definitions resulting from strategic decisions for the company's business.”

Just as in the definition of any planning, in the economic feasibility study of an investment project it is necessary to initially define the questions to be answered.

In an industrial environment, for example, some of the questions to be answered in the feasibility analysis are: Where to build a new plant? Use inputs from supplier A or supplier B? What kind of machinery do you invest in? Search for financing line or use equity for expansion?

In a startup, some questions to be answered in an economic feasibility study are: is it worth buying the license of certain software or using an open source equivalent?

These are examples of typical questions that motivate the study of economic and financial viability in the business environment. The following are the main points to be taken into account in this process.

b) Revenue, costs and expenses in the feasibility analysis

The first step in conducting an economic and financial feasibility study is to know the company's revenues, or the investment project being analyzed. It should be noted that the revenues and expenses to be projected for feasibility analyzes are usually made using the cash regime.

The projection of revenues

Revenue, as Casarotto (2016, p.161) explains, in most cases represents the total planned to be sold multiplied by the market price of the products. This assumes that the market will absorb the amount that will be produced while maintaining the same market price.

The projection of revenues within the economic viability analysis should be flexible, contemplating several hypothetical scenarios. Each scenario will contain different information about the price of products, quantity sold, costs, among others.

The projection of costs and expenses

As important as the revenue projection, is the cost and expense statement. The costs represent the costs associated with the production, both of product and of services.

Expenses are expenses not directly associated with the production process, but whose purpose is to increase the organization's revenue generation capacity. This, in fact, should be the motivation of any expenditure incurred in an organization.

The Projection of the cash flow

Knowing the composition of the cash flow of the company being analyzed is essential to carry out projections in the analysis of economic and financial feasibility. For this, it is necessary to have in hand the withdrawals of revenues, costs and expenses involved in the production processes, as already mentioned.

The cash flow of an investment project represents the balance of everything that will enter minus all that will come out of resources throughout the execution of the project.

$$\text{Cash flow} = (\text{Amounts to be received}) - (\text{Costs and expenses to be paid})$$

Cash flow is determined by the cash accounting regime - unlike accounting profit, which is calculated based on the accrual basis.

Casarotto (2016) explains that "based on projections of results and projections of amortizations of financing, cash flows can be projected for the enterprise and for the

shareholder. "The author further recommends that projections be worked out in a way that the cash and competence regimes are unified.

Methods of economic and financial feasibility analysis

To make the economic and financial feasibility analysis of an investment project there are some methods to be applied in the cash flow projections carried out.

Among the main methods are discounted payback, net present value (NPV) and internal rate of return (IRR and IRRM).

In the application of economic feasibility analysis methods, a rate is used that will serve for comparison purposes and also to bring present value future cash flows to present value. This rate is the MAR - Minimum Attraction Rate.

Usually the MAR to be used in the analysis of an investment project is calculated based on the cost of capital of the company, in other words, the cost of the company has its own resources (return required by shareholders or shareholders) and third parties (debt) within its patrimonial structure.

The MAR can also represent the status quo, keep the resources applied in the current project or in a risk-free financial application, for example.

The use of the IRRM to estimate the return on an investment project

One of the main questions that every manager always wants to answer is: what will be the return of this project?

This is a difficult question to answer, as there are several methods of calculating the return on an investment project.

In this sense, Casarotto (2016) is positioned to defend the Internal Rate of Return Modified method, the IRRM.

The IRRM is a relative measure, expressed as a percentage and at the same periodicity of the cash flows. For example, if the cash flows projected in an economic and financial feasibility study are annual, then the result of the IRRM calculation will be an annual rate.

The great advantage of IRRM, and this is also one of the arguments of Casarotto (2016), is that it works well with any type of cash flow, whether it is conventional flows (just a change of signal) or not conventional (more than one change of signal).

In the economic feasibility study, the IRRM will be a better alternative than the conventional IRR to estimate the return of the project whenever any of the next two ask to have a "no" per answer:

- a) Is there real root?
- b) If it exists, can it be reapplied at the same rate?

Sensitivity analysis in the feasibility study

The economic viability study would be much easier if in practice there were not so many factors that could positively or negatively impact the projection of cash flows of an investment project.

Due to the risks and uncertainties of the real world, different scenarios must be considered before making any strategic decision to accept or reject a project.

Sensitivity analysis represents a way of taking uncertainty into account in the feasibility study. There is no specific and common methodology in the literature for such an analysis, but the important thing is to understand the conceptual ideal of sensitivity analysis of working with different scenarios.

Casarotto (2016) states: "The analysis of the return to different rates of reapplication, through the calculation of the IRRM, is the first important point of the sensitivity analysis. There are, however, other important factors to consider. With the globalization of the economy, an important variable is the sensitivity of the project to exchange rate variations. Raw materials and products being marketed to and from many countries require consistent designs that are resistant to exchange rate variations. "

The creation of scenarios should consider variations in critical factors for the practical execution of a project, such as inflation, input or raw material prices, exchange variation, salary and labor, market demand, cultural issues, among other factors. These factors impact revenue, costs, or expenses.

One tip is to work with scenarios with the isolated impact of each variable. This way it is possible to identify the factors that are most critical to make a project unfeasible. If possible, these factors can be worked out and their impact reduced. But if they are exogenous issues, out

of control of the decision maker - such as country inflation, for example - then the sensitivity analysis may reinforce the idea of rejecting the project in question.

Conclusion

The purpose was to present the main topics to be taken into account in an economic and financial feasibility study of an investment project. The theme is vast, but extremely important.

A good feasibility study will take into account the following steps:

1. Survey and projection of revenues, costs and expenses.
2. Projection of cash flows.
3. Application of economic engineering methods (investment analysis).
4. Sensitivity analysis.



5 SOLUTION PROPOSAL

5.1 Current Situation

The FTL uses 1,660 sleepers for each kilometer of line. For the purpose of this study, the distance between the cities of São Luis (MA) and Teresina (PI), we have a distance of 492 kilometers, which means a total of 816,720 sleepers (492 km x 1,660 sleepers per km). Of this total, about 53% are considered inserviceable sleepers, that is, they do not have adequate fixation capacity.

With this permanent track scenario, a series of restrictive measures are necessary in order to maintain and guarantee operational safety.

The reflection of this, are operational indicators with the results below:

	Average speed	18,3 km/h
	Commercial Speed	10,46 km/h




	Cicle	7,3 days
	Transit Time	41 h 06
	Energy Efficiency	7,14 liters/MGTK

Table 2 – Current Operational Indicators

To assess the scenarios, we will only use the fuel loads as a reference for the calculations. The volume of fuels transported each month, on average, in 2017 was 51,092 tons.


	Fuels	51.92 tons / month
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Table 3 – Current Fuel tons transported

5.2 Solution 1 – Wooden Sleepers

In order to modernize this stretch, improve operational safety and increase transport capacity, we will describe below the investments required for this modernization using wooden sleepers.

Considering the rules established in resolution 278 on the transport of dangerous products (ANTT regulation) that determines the level of adequate good sleepers for each segment (tangents and curves) will require the implantation of 360,000 new wooden sleepers.

The unit cost of wood sleepers (including freight and taxes) = R\$ 146.24

The cost of fastening items for each sleeper (support plate, tirefond and retensors) = R\$ 170.33

The installation cost per unit = R\$ 173.76

The total cost of each installed sleeper = R\$ 490.33

The total investment in wooden sleepers = 360,000 units x R\$ 490.33 = R\$ 176.5 million reais.

Considering the concession period up to 2057, the sustaining cost to maintain the track at the post modernization level will be R\$ 11.3 million per year.

The result of the investments will change the operational indicators to:






	KPI	Before	After
	Average speed	18,3 km/h	25 km/h
	Commercial Speed	10,46 km/h	13,8 km/h
	Cicle	7,3 days	4 days
	Transit Time	41 h 06	31 h 13
	Energy Efficiency	7,14 liters/MTKG	6,18 liters/ MGTK

Table 4 – Future Operational Indicators post wooden sleepers modernization

The above results, in addition to bringing cost savings, will increase the railroad's transportation capacity because, with the same rolling stock, it will be possible to generate higher revenues. Only in the fuel segment it will be possible to increase from 17,808 freight cars loaded per year to 32,400 freight cars loaded per year.

This increase in the volume of cargo will bring revenue growth in the order of R\$ 45.8 million reais per year.

In addition, by improving energy efficiency and using the same GTK of the last 12 months, there will be a reduction in fuel costs, used in the transportation of cargo, in the order of R\$ 1.6 million reais per year.

5.3 Solution 2: Concrete Sleepers

With the same goal of upgrading the railroad, improving operational safety and increasing transport capacity, we will describe below the investments required using concrete sleepers.

In the case of the use concrete sleepers, the company must perform the complete replacement of wooden sleepers, and it is important to stress that the number of concrete sleepers will be greater than that of wooden sleepers.

In the analysis of the use concrete sleepers, the company will implant 1,550 units for each kilometer of permanent way. Considering the 492 km objects of this study, it will be necessary then:

492 km x 1,550 sleepers, totaling 762,600 concrete sleeper necessary for the complete remodeling of the stretch between the cities of São Luis (MA) and Teresina (PI).

The unit cost of the concrete sleeper (including taxes, and without freight, once the plant is 50 meters from the FTL line) is R\$ 170.00 / unit.

The cost of the fastening material for each sleeper (Elastic fixing and neoprene pads) is R\$ 36.00 / set.

The installation cost is R\$ 202,30 / unit.

With these data, the total cost of each installed concrete sleeper is R\$ 408.30 / unit and the total investment in the acquisition and replacement of wooden sleepers by concrete sleepers is in the order of R\$ 311.4 million (762,600 units x R\$ 408,30).

Considering the concession period of the Transnordestina Logística - FTL Railroad until 2057, the sustaining cost to maintain the permanent route at the post modernization level will be R\$ 5.6 million each year.

The result of the investments will change the operational indicators to:






	KPI	Before	After
	Average speed	18,3 km/h	40 km/h
	Commercial Speed	10,46 km/h	18,3 km/h
	Cicle	7,3 days	3,25 days
	Transit Time	41 h 06	23 h 32
	Energy Efficiency	7,14 litros/MGTK	4,42 litros/ MGTK

Table 5 – Future operational indicators post concrete sleepers modernization

The above results, in addition to bringing cost savings, will increase the railroad's transportation capacity because, with the same rolling stock, it will be possible to generate higher revenues. Only in the fuel segment it will be possible to increase from 17,808 freight cars loaded per year to 39,600 freight cars loaded per year.

This increase in the volume of cargoes will bring revenue growth in the order of R\$ 67.9 million reais per year.

In addition, by improving energy efficiency and using the same GTK of the last 12 months, there will be a reduction in fuel costs, used in the transportation of cargoes, in the order of R\$ 4.7 million reais per year.

Another possible gain refers to the sleepers that can be reused, that is, when the concrete sleepers are implanted, it will be possible to reuse wooden sleepers that are still in good condition and apply in stretches where wood sleepers will still be kept.

Considering the 492 kilometers of the target stretch of this study, it will be possible to reuse about 151,700 wooden sleepers.

If we consider an economy that does not require the acquisition of these materials and maintains its proportional useful life (less than a new wood sleeper), we will have an additional saving in the order of R\$ 12.8 million (151,700 units x R\$ 84,00).

5.4 Comparative summary table: Wood vs. Concrete

Following the surveys of investment information required for each type of sleeper, as well as the results of each of the modernization options, we present in the tables below a summary of the improvements, separated between: operational indicators and financial indicators.

Comparative Operational Indicators







FUELS IN WAGONS TANKS	AVERAGE SPEED 	COMMERCIAL SPEED 	TOTAL CYCLE (d) 	TONS TRANSPORTED (t) 	TRANSIT TIME 	ENERGY EFFICIENCY 
Current Sleepers	18,3	10,46	7,3	51,1	41:06	7,14
Wood sleepers	25 ↑ 37%	13,8 ↑ 32%	4 ↓ 45%	92,7 ↑ 81%	31:13 ↓ 24%	6,18 ↓ 13%
Concrete sleeper	40 ↑ 119%	18,3 ↑ 75%	3,25 ↓ 55%	113,2 ↑ 122%	23:32 ↓ 43%	4,42 ↓ 38%

Table 6 – Comparative Operational Indicators Wooden x Concrete

Investment analysis (R\$)









APPLICATION OF SLEEPERS	INITIAL INVESTMENT 	ANNUAL SUSTAINING 	SUSTAINING FOR 35 YEARS 	ADDITIONAL ANNUAL REVENUE 	ADDITIONAL REVENUE 35 YEARS 	ECONOMY WITH ANNUAL ENERGY EFFICIENCY 	ECONOMY WITH ENERGY EFFICIENCY 35 YEARS 	REUSABLE SLEEPERS 
Wood sleepers	R\$ 176,5 MM	R\$ 11,3 MM	R\$ 395,5 MM	R\$ 45,8 MM	R\$ 1,603 BI	R\$ 1,6 MM	R\$ 56 MM	R\$ 0 MM
Concrete sleepers	R\$ 311,4 MM	R\$ 5,6 MM	R\$ 196 MM	R\$ 67,9 MM	R\$ 2,376 BI	R\$ 4,7 MM	R\$ 164,5 MM	R\$ 12,8 MM
Variação (C-M)	R\$ 134,9 MM ↑	R\$ 5,7 MM ↓	R\$ 199,5 MM ↓	R\$ 22,1 MM ↑	R\$ 773 MM ↑	R\$ 3,1 MM ↑	R\$ 108,5 MM ↑	R\$ 12,8 MM ↑

Table 7 – Comparative Investment analysis Wooden x Concrete

After the understanding of the values required for the investments in each type of sleepers (wood or concrete), as well as the return that each one will offer, the first task was to evaluate if the difference of the gains over the time, brought to present value, would justify an additional investment to deploy concrete sleeper and not wooden sleeper.

	WOOD	CONCRETE	VARIATION
Investment	- 176,5	- 311,4	- 134,9
Sustaining	-	-	5,7
Revenues	45,8	67,9	22,1
Energy Efficiency	1,6	4,7	3,1
Reusable Sleepers	-	12,8	12,8

Table 8 – Results and variation of the comparison - Unit: R\$ x 10⁶

Based on the information of the variation described in the previous table, a cash flow was developed as follows:

Cash Flow for the Variation											
	2019	2020	2021	2022	2023	2024	2025	2030	2040	2050	2057
(-) Investment	- 33,7	- 33,7	- 33,7	- 33,7							
(+) Reusable Sleepers	3,2	3,2	3,2	3,2							
(+) Additional Revenues					22,1	22,1	22,1	22,1	22,1	22,1	22,1
(+) Energy Efficiency Economy					3,1	3,1	3,1	3,1	3,1	3,1	3,1
(-) Sustaining					6	6	6	6	6	6	6
EBIT					30,9	30,9	30,9	30,9	30,9	30,9	30,9
TAX (34%)					- 10,5	- 10,5	- 10,5	- 10,5	- 10,5	- 10,5	- 10,5
NOPAT					20,4	20,4	20,4	20,4	20,4	20,4	20,4
Cash Flow (year)	- 30,5	- 30,5	- 30,5	- 30,5	20,4	20,4	20,4	20,4	20,4	20,4	20,4
Accumulated Cash Flow	- 30,5	- 61,1	- 91,6	- 122,1	- 101,7	- 81,3	- 60,9	41,1	245,0	448,9	591,7

WACC	8%
NPV	R\$ 73,60

IRR	14%
PAYBACK	9 years 12 months

Table 9 – Cash flow of the variation - Unit: R\$ x 10⁶

The above cash flow considered the entire concession period (up to 2057) and just for a better view, the table above shows only a few years.

According to the cash flow above, it was evidenced that the variation of the additional revenues and cost reduction between concrete and wood sleepers, justify the realization of greater investments for the implantation of concrete sleepers.

After validation that the investment in concrete sleepers is worth more than in wooden sleepers, the cash flow was elaborated considering only the concrete sleeping scenario, using the total investments and the financial economic potential of increase of revenues and cost savings to find the viability of the whole investment.

Cash Flow Concrete Sleepers											
	2019	2020	2021	2022	2023	2024	2025	2030	2040	2050	2057
(-) Investment	- 77,9	- 77,9	- 77,9	- 77,9							
(+) Reusable Sleepers	3,2	3,2	3,2	3,2							
(+) Additional Revenues					67,9	67,9	67,9	67,9	67,9	67,9	67,9
(+) Energy Efficiency Economy					4,7	4,7	4,7	4,7	4,7	4,7	4,7
(-) Sustaining					-	-	-	-	-	-	-
EBIT					72,6	72,6	72,6	72,6	72,6	72,6	72,6
TAX (34%)					- 24,7	- 24,7	- 24,7	- 24,7	- 24,7	- 24,7	- 24,7
NOPAT					47,9	47,9	47,9	47,9	47,9	47,9	47,9
Cash Flow (year)	- 74,7	- 74,7	- 74,7	- 74,7	47,9	47,9	47,9	47,9	47,9	47,9	47,9
Accumulated Cash Flow	- 74,7	- 149,3	- 224,0	- 298,6	- 250,7	- 202,8	- 154,9	84,7	563,9	1.043,0	1.378,5

WACC	8%
NPV	R\$ 163,22

IRR	13%
PAYBACK	10 years 3 months

Table 10 – Cash flow of the total project for concrete sleeper modernization - Unit: R\$ x 10⁶

6 CONCLUSIONS AND RECOMMENDATIONS

The present study allowed the understanding of two very important points for the rail freight business.

The first conclusion refers to the importance of a strategic thinking that allows the company to evaluate a more comprehensive and long-term scenario with growth potential.

This is due to the fact that if the investments are only considered as a value for each year in isolation, often not allowing to see all the possibilities and scenarios.

In the present study, the choice of a specific section (between the cities of São Luis and Teresina), where the main loads pass, and which also has the potential of greater market share associated with a more robust investment plan, multiannual, made it possible to evaluate and conclude that migrating to a new type of sleeper will offer the company a much greater potential.

In addition, although the study was absolutely conservative in relation to the potential returns, the economic-financial feasibility study was positive in relation to the investments required to implement concrete sleepers in the studied section.

This assertion is based on the fact that only the potential to increase a single load (fuels), that is, the improvement in operational and transportation indicators, will also be reflected in other loads and other operating costs, such as reduction in the number of train drivers, since with the reduction in transit time, secondments could be reduced.

The use of the appropriate tools, as well as the correct understanding of the processes and where each improvement can affect their outcomes, allowed for a coherent analysis about the company's needs and also offer information for the correct decision making on one type of investment or another.

In time, it should be emphasized that the present study was presented to the company and approved.

The project of implantation of concrete sleepers in the stretch between São Luis and Teresina is currently underway.

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