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Implementing Lean Tools for Workflow Efficiency in Construction

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Implementing Lean Tools for Workflow Efficiency in Construction

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I'd like to take this section to reflect on my academic journey, which has equipped me with the scientific and cross-functional skills necessary to complete this thesis. I began my studies in Mechanical Engineering at Sorbonne University (BSc) and Applied Mathematics, then continued at ENSAM, where I specialized in Mechanical, Electrical, and Industrial Engineering. Finally, I completed my studies with a specialization in Production Engineering at Poli USP.

This dual degree holds special meaning as it started as a personal challenge, and this thesis represents the culmination of that challenge I set for myself. Arriving in Brazil with limited knowledge of Portuguese, I managed, to learn the language, succeed in my classes, secure an internship, and work effectively. I am proud to have successfully met this personal challenge.

Lastly, I want to thank my family for their unwavering support throughout this journey. Their belief in me and their encouragement were crucial, especially during challenging times, and helped me complete this incredible endeavor.

ABSTRACT

This thesis explores the application of Lean methodologies in the context of project management, focusing on the implementation of Value Stream Mapping (VSM) and the 5S methodology. Lean methodologies, originally developed to enhance productivity by minimizing waste in manufacturing, are applied here to streamline data management and improve efficiency in complex construction projects. The research aims to evaluate how Lean tools can address common inefficiencies in project workflows, such as manual data entry errors, delays in data transmission, and fragmented communication. Through a qualitative case study approach, key processes were mapped, and targeted improvements were proposed and tested, emphasizing automation and standardization. Results show that the adoption of VSM and 5S led to significant improvements in data accuracy, workflow efficiency, and overall productivity. The study highlights the adaptability of Lean principles in complex project management and provides recommendations for further scalability within the construction sector.

Keywords:

Lean methodologies, Value Stream Mapping, 5S methodology, project management, construction efficiency.

SUMMARY (in Portuguese)

Esta tese explora a aplicação de metodologias Lean no contexto de gestão de projetos, com foco na implementação do Mapeamento do Fluxo de Valor (VSM) e da metodologia 5S. As metodologias Lean, originalmente desenvolvidas para aumentar a produtividade ao minimizar desperdícios na manufatura, são aqui aplicadas para otimizar a gestão de dados e melhorar a eficiência em projetos complexos de construção. A pesquisa tem como objetivo avaliar como as ferramentas Lean podem resolver ineficiências comuns nos fluxos de trabalho de projetos, como erros manuais na inserção de dados, atrasos na transmissão de informações e comunicação fragmentada. Por meio de um estudo de caso qualitativo, processos-chave foram mapeados, e melhorias direcionadas foram propostas e testadas, com ênfase na automação e padronização. Os resultados mostram que a adoção do VSM e do 5S levou a melhorias significativas na precisão dos dados, na eficiência dos fluxos de trabalho e na produtividade geral. O estudo destaca a adaptabilidade dos princípios Lean na gestão de projetos complexos e fornece recomendações para maior escalabilidade no setor da construção civil.

Palavras-chave:
Metodologias Lean, Mapeamento do Fluxo de Valor, metodologia 5S, gestão de projetos, eficiência na construção civil.

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1 INTRODUCTION

1.1 Background

Lean methodologies, rooted in the Toyota Production System (TPS), revolutionized manufacturing by emphasizing the elimination of waste, continuous improvement, and creating value from the customer's perspective. Lean focuses on systematically identifying and reducing non-value-adding activities, which Toyota originally framed as the "seven wastes" — defects, overproduction, waiting, non-utilized talent, transportation, inventory, motion, and extra processing (PASQUALINI; ZAWISLAK, 2005; MILETIĆ; MILETIĆ, 2017). Over decades, Lean principles have extended beyond manufacturing to industries such as healthcare, education, and construction, where they have demonstrated significant potential to enhance efficiency and reduce costs (HOHMANN, 2010; UGHETTO, 2020).

Industry 4.0, also known as the Fourth Industrial Revolution, marks a paradigm shift in industrial practices, driven by the integration of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), robotics, cloud computing, and big data analytics. Unlike previous industrial revolutions that relied on mechanization, electrification, or automation, Industry 4.0 aims to create interconnected and intelligent systems capable of self-diagnosing and self-optimizing to enhance productivity (GIAMPIERI, 2020; GIL-VILDA et al., 2021). At its core, Industry 4.0 envisions "smart factories" where machines, products, and humans communicate seamlessly, enabling adaptive, real-time decision-making (GIAMPIERI, 2020).

The integration of Lean methodologies with Industry 4.0 concepts—often referred to as Lean 4.0—seeks to leverage digital technologies to amplify Lean's core objectives of waste reduction and value creation. For example, tools like real-time data monitoring, digital twins, and predictive maintenance enhance traditional Lean techniques such as Value Stream Mapping (VSM) and 5S methodology (GIL-VILDA et al., 2021; GIAMPIERI, 2020). However, the intersection of Lean and Industry 4.0 is not without challenges. While Lean emphasizes human-centric processes and manual problem-solving, Industry 4.0 relies heavily on automation and digitization, creating a tension that organizations must navigate (GIAMPIERI, 2020; PETTERSEN, 2008).

The construction sector presents unique challenges in applying Lean 4.0 due to its intrinsic characteristics. Unlike manufacturing, where processes are repetitive and occur within controlled environments, construction projects are often dynamic, one-off undertakings with high variability in workflows, materials, and environments. Additionally, the adoption of technology in construction lags behind other industries, partly due to fragmentation, the involvement of multiple stakeholders, and resistance to change (PASQUALINI; ZAWISLAK, 2005). Traditional construction practices often rely on manual coordination and siloed decision-making, making the transition to integrated digital systems and Lean practices complex.

Adopting Lean 4.0 in construction requires addressing both technical and cultural barriers. The fragmented nature of construction supply chains can make the implementation of real-time data systems or process standardization difficult. Moreover, aligning the human-centric philosophy of Lean with the automated, data-driven approach of Industry 4.0 demands rethinking traditional roles and workflows. Despite these challenges, successful integration holds significant potential for the construction industry, enabling greater efficiency, reduced project timelines, and improved stakeholder collaboration (PASQUALINI; ZAWISLAK, 2005; OLIVEIRA et al., 2018).

1.2 Problem Statement

SNEF Brasil, a subsidiary of the multinational SNEF Group, operates in the engineering, electrical installations, and industrial maintenance sectors, delivering projects that demand high levels of customization and precision. With a focus on large-scale infrastructure and industrial construction, SNEF Brasil's projects involve diverse stakeholders, strict deadlines, and tight budgets. These factors inherently challenge efficiency, resource optimization, and communication, making the adoption of Lean methodologies and digital innovation crucial for competitiveness.

Despite the recognized potential of Lean principles to streamline processes and reduce waste, their application in SNEF Brasil is constrained by the dynamic and fragmented nature of construction workflows. Unlike manufacturing, where processes are repetitive and controlled, construction projects face variability in schedules, unforeseen disruptions, and a reliance on manual coordination. Introducing Lean tools such as Value Stream Mapping (VSM) and 5S in this context is further complicated by the lack of standardized processes and the resistance to cultural change within the industry.

The integration of Industry 4.0 technologies into SNEF Brasil’s Lean framework presents additional complexities. While Industry 4.0 offers tools like real-time data tracking, predictive analytics, and automation, their successful implementation requires robust infrastructure, a shift toward collaborative digital ecosystems, and significant workforce training. At SNEF Brasil, the absence of integrated digital solutions and reliance on siloed decision-making limit the scalability of Lean 4.0 approaches, exacerbating inefficiencies and communication gaps across project teams.

This thesis addresses the critical challenge of adapting and integrating Lean 4.0 methodologies within the operational framework of SNEF Brasil. Specifically, it aims to explore how Lean tools, enhanced by Industry 4.0 technologies, can be tailored to the unique needs of construction projects to improve workflow efficiency, resource allocation, and stakeholder collaboration. By identifying bottlenecks and proposing actionable strategies, this study seeks to bridge the gap between Lean theory and practical application in construction environments. This represents not only a technical but also a cultural transformation for SNEF Brasil, pushing the company toward a future defined by agility, innovation, and operational excellence.

1.3 Research Question

This thesis seeks to answer the following research question: ***How can the implementation of LEAN methodologies, specifically Value Stream Mapping (VSM) and the 5S methodology, improve data management and project productivity in complex construction projects at SNEF Brasil?***

1.4 Objectives

The primary objectives of this research are:

- To assess the impact of Value Stream Mapping (VSM) on identifying inefficiencies in data management processes.
- To evaluate the effectiveness of the 5S methodology in standardizing and improving data workflows.
- To determine how Lean methodologies contribute to enhanced project productivity and overall efficiency at SNEF Brasil.

1.5 Key Terms

LEAN

Lean is a systematic approach that seeks to improve organizational efficiency by identifying and eliminating waste while focusing on activities that add value from the customer's perspective. Originally developed by Toyota as part of its Production System (TPS), Lean is guided by five key principles: defining value, mapping the value stream, creating flow, establishing pull, and pursuing perfection (PETTERSEN, 2008; UGHETTO, 2020). Its tools and techniques, such as Value Stream Mapping (VSM) and Kanban, aim to enhance productivity, reduce costs, and improve customer satisfaction by streamlining processes and eliminating non-value-adding steps (PASQUALINI; ZAWISLAK, 2005; GIL-VILDA et al., 2021).

LEAN 4.0

Lean 4.0 refers to the integration of Lean principles with Industry 4.0 technologies to further enhance operational efficiency. This evolution incorporates advanced digital tools, such as IoT, big data analytics, and artificial intelligence, to provide real-time insights and enable automation (GIAMPIERI, 2020; GIL-VILDA et al., 2021). For instance, while traditional Lean relies on human-centric problem-solving, Lean 4.0 utilizes data-driven decision-making to optimize processes dynamically. Examples include using predictive analytics for maintenance and deploying digital twins to simulate and improve workflows (MILETIĆ; MILETIĆ, 2017; GIL-VILDA et al., 2021). However, Lean 4.0 also presents challenges in aligning automation with Lean's emphasis on human involvement and continuous improvement (GIAMPIERI, 2020).

Industry 4.0

Industry 4.0, or the Fourth Industrial Revolution, introduces smart factories where physical systems are interconnected via digital technologies. It is characterized by the integration of IoT, AI, robotics, and cloud computing to create autonomous, adaptive, and intelligent production systems (GIAMPIERI, 2020; GIL-VILDA et al., 2021). This paradigm shift allows for real-time monitoring, predictive capabilities, and improved decision-making across manufacturing and service sectors. For instance, IoT sensors enable real-time tracking of material flow, while AI algorithms enhance quality control by identifying defects automatically (GIL-VILDA et al., 2021; MILETIĆ; MILETIĆ, 2017).

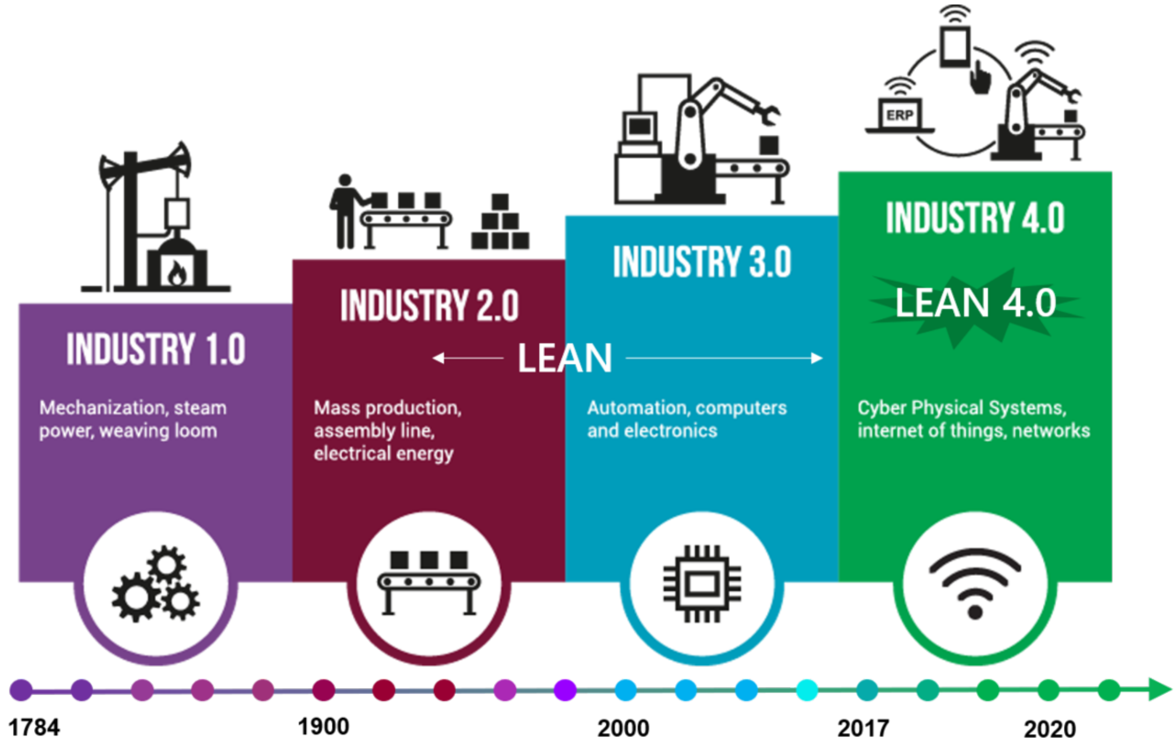


Figure 1: Industry 4.0 – Illustration[1]

Value Stream Mapping (VSM)

VSM is a Lean tool designed to visualize, analyze, and improve the flow of materials and information required to deliver a product or service to the customer. It identifies value-adding and non-value-adding steps, enabling organizations to streamline their processes and reduce waste (PASQUALINI; ZAWISLAK, 2005). VSM is particularly useful in identifying bottlenecks and inefficiencies, making it a critical tool in Lean 4.0 when combined with real-time data systems to enable dynamic mapping of value streams (PASQUALINI; ZAWISLAK, 2005; GIL-VILDA et al., 2021).

5S Methodology

The 5S methodology is a workplace organization tool rooted in Japanese management practices, consisting of five principles: Seiri (Sort), Seiton (Set in order), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain). These principles aim to create a clean, organized, and efficient workplace that supports productivity and safety (HOHMANN, 2010; OLIVEIRA et al., 2018). As written by Oliveira et al (2018, p. 4):

[1] Reference: CORONATODAYS. La mejora de la productividad en un entorno lean y de industria 4.0. 2020. Available at: https://coronatodays.com/la-mejora-de-la-productividad-en-un-entorno-lean-y-de-industria-4-0-af2020/. Accessed on: 23 Oct. 2024

> *Sense of utilization: Only what is necessary should remain in the workplace; what is not useful should not remain occupying space.*
>
> *Sense of organization: Materials and tools need to be organized so that as little time as possible is lost in searching for them.*
>
> *Sense of cleanliness: An environment must be clean to be pleasant; a dirty environment hinders the worker's performance and conveys an image of laxity.*
>
> *Sense of health: Suppression of elements that can generate discomfort in the workplace, focusing on promoting those that can cause well-being.*
>
> *Sense of self-discipline: This is related to acceptance, willpower, hard work, diligence, and persistence.*

Implementing 5S is often seen as a foundational step in Lean transformation, as it establishes the organizational discipline necessary for sustained improvement. For example, Seiri focuses on removing unnecessary items, while Seiton emphasizes organizing tools and materials for efficient access (HOHMANN, 2010; OLIVEIRA et al., 2018).

1.6 Structure of the Thesis

This thesis is divided into six parts, each one addressing a crucial aspect of the research process:

2. **Literature Review** — Provides a comprehensive review of the academic literature on Lean methodologies, focusing on their application in production engineering and the construction industry. It explores the evolution of Lean principles and their role in improving operational efficiency, with a particular focus on the construction sector.

3. **Methodology** — Outlines the research design, data collection methods, and analytical tools used to evaluate the impact of Lean tools on project management processes at SNEF Brasil. A qualitative case study approach is employed to ensure in-depth analysis of the company's workflows.

4. **Company Background and Process Analysis** — Offers a detailed examination of SNEF Brasil's project management processes before the

implementation of Lean methodologies. This chapter highlights the inefficiencies and challenges that necessitated Lean interventions.

5. **Lean Implementation and Results** — Discusses the implementation of Lean tools such as Value Stream Mapping (VSM) and the 5S methodology at SNEF Brasil. It presents the outcomes of these implementations, including improvements in data accuracy, process efficiency, and overall productivity.

6. **Conclusion** — Summarizes the research findings, reflecting on the impact of Lean methodologies on project management at SNEF Brasil. It also offers recommendations for future implementation and scalability of Lean practices in the construction sector, emphasizing the potential for continuous improvement and efficiency gains.

2 LITERATURE REVIEW

This chapter provides a comprehensive review of key academic articles exploring the principles, tools, and evolution of Lean methodologies. The focus is on their transition from traditional manufacturing contexts to broader applications in Industry 4.0 and data management. By examining foundational concepts like Value Stream Mapping (VSM) and the 5S methodology, the chapter highlights how Lean has adapted to address challenges in dynamic and data-driven environments.

Each article contributes unique perspectives on Lean's development and its integration with technologies like IoT, artificial intelligence, and predictive analytics. The chapter synthesizes these contributions, addressing their implications for industries such as construction, healthcare, and IT, and setting the stage for an in-depth discussion of Lean's potential in modern production systems.

2.1 Summary of Key Articles

The following table summarizes the key academic articles reviewed in this chapter. Each entry highlights the authors, the title of the work, and a concise summary of its main contributions to the understanding of Lean methodologies. This structured overview provides a foundation for analyzing Lean's evolution and its integration with Industry 4.0.

Authors	Title	Summary
M. Miletić & I. Miletić (2017)	*Lean Methodology and Its Derivatives Usage for Production Systems in Modern Industry*	Examines Lean tools like 5S and VSM in manufacturing, emphasizing workplace organization, continuous improvement, and adaptability to other sectors, such as healthcare and IT.
F. Gil-Vilda, J. A. Yagüe-Fabra & A. Sunyer (2021)	*From Lean Production to Lean 4.0: A Systematic Literature Review with a Historical Perspective*	Reviews Lean's evolution into Lean 4.0, emphasizing the integration of digital technologies like IoT and big data into Lean methodologies to address modern, data-driven challenges.

Authors	Title	Summary
J. Pettersen (2008)	*Defining Lean Production: Some Conceptual and Practical Issues*	Critically analyzes the varying definitions of Lean production, its theoretical underpinnings, and its adaptability across organizational contexts, emphasizing waste elimination and continuous improvement.
F. Pasqualini & P. A. Zawislak (2005)	*Value Stream Mapping in Construction: A Case Study in a Brazilian Construction Company*	Investigates the application of VSM in construction, adapting it to enhance workflow efficiency and reduce waste, highlighting its flexibility beyond manufacturing.
P. Ughetto (2020)	*Comprendre le Lean pour mieux le maîtriser*	Discusses Lean's productivity improvements through waste reduction and workflow enhancement, cautioning against its misuse purely for cost-cutting without considering human factors.
M. Giampieri (2020)	*Impact of Industry 4.0 Management Systems on Lean Production*	Explores the interplay between Industry 4.0 and Lean, highlighting opportunities to enhance Lean practices through automation and real-time data while addressing cultural and technical barriers.
S. Oliveira et al. (2018)	*Implementação da metodologia 5S e suas influências positivas nas indústrias*	Examines the impact of 5S on workplace organization, productivity, and employee well-being, providing practical guidelines for its implementation as a foundation for broader Lean initiatives.
D. Garnier (2011)	*La Value Stream Mapping: Un outil de représentation des procédés pour*	Explores VSM in the pharmaceutical industry, outlining its ability to identify bottlenecks and adapt workflows for process optimization.

Authors	Title	Summary
	l'amélioration Lean appliqué à l'industrie pharmaceutique	
C. Hohmann (2010)	*Guide pratique des 5S et du management visuel*	Offers a practical guide to implementing the 5S methodology, emphasizing the role of visual management in improving efficiency and organization with real-world examples.

Table 1: Summary of Key Articles

2.2 Evolution and Adaptability of Lean Methodologies

Lean methodologies have evolved significantly since their inception in the Toyota Production System (TPS). Originally designed to streamline manufacturing processes through waste elimination and value creation, Lean's principles were codified in practices such as Just-In-Time (JIT) production, Kanban systems, and workplace organization methods like 5S (MILETIĆ; MILETIĆ, 2017; PETTERSEN, 2008). The key principles of Lean—defining value, mapping the value stream, establishing flow, enabling pull, and striving for perfection—remain the foundation of its application across industries (PASQUALINI; ZAWISLAK, 2005; UGHETTO, 2020). Over time, these principles have proven adaptable to diverse sectors such as healthcare, construction, and IT, showcasing Lean's flexibility (GIL-VILDA et al., 2021; HOHMANN, 2010).

The integration of Lean with digital technologies, leading to what is now called Lean 4.0, represents a major milestone in its evolution. Industry 4.0 introduces advanced tools like the Internet of Things (IoT), big data analytics, artificial intelligence, and robotics, which are being integrated into Lean practices to create smarter, more adaptive systems (GIAMPIERI, 2020; GIL-VILDA et al., 2021). For instance, traditional Lean tools such as Value Stream Mapping (VSM) are being enhanced by real-time data capabilities, allowing dynamic analysis of processes rather than static snapshots (PASQUALINI; ZAWISLAK, 2005). Similarly, predictive maintenance—enabled by IoT and AI—aligns with Lean's focus on minimizing downtime by addressing potential failures proactively (GIL-VILDA et al., 2021; GIAMPIERI, 2020).

Lean methodologies have also demonstrated significant adaptability in environments outside of manufacturing. For example, Ughetto (2020) highlights how Lean has been effectively applied in healthcare, where reducing patient wait times and streamlining administrative workflows mirror Lean's core goals (UGHETTO, 2020). In the construction industry, Pasqualini and Zawislak (2005) adapted Lean tools such as VSM to address the sector's unique challenges, including variability in workflows and the dynamic nature of projects (PASQUALINI; ZAWISLAK, 2005). These adaptations show how Lean principles can be tailored to fit the specific needs and constraints of different industries.

However, the transition to Lean 4.0 introduces challenges in maintaining Lean's human-centric philosophy. While Lean emphasizes employee involvement and problem-solving at all organizational levels, Industry 4.0 technologies often focus on automation and data-driven decision-making. This shift requires organizations to balance the benefits of digital tools with the need to sustain human creativity and collaboration, as highlighted by Gil-Vilda et al. (2021) and Pettersen (2008) (GIL-VILDA et al., 2021; PETTERSEN, 2008). Cultural shifts and workforce training are critical to ensuring that digital transformations align with Lean's emphasis on continuous improvement (GIAMPIERI, 2020; OLIVEIRA et al., 2018).

In summary, the evolution of Lean methodologies from their manufacturing roots to Lean 4.0 reflects both their adaptability and the increasing complexity of modern production environments. While Lean's core principles remain relevant, their integration with advanced technologies has expanded their applicability and impact across sectors. However, successful implementation of Lean 4.0 requires a thoughtful approach to reconcile its digital innovations with the foundational human-centric practices of Lean (MILETIĆ; MILETIĆ, 2017; GIL-VILDA et al., 2021).

2.3 Core Lean Tools: VSM and 5S

Value Stream Mapping (VSM) and the 5S methodology are cornerstone tools of Lean methodologies, widely recognized for their effectiveness in identifying inefficiencies and fostering workplace organization. These tools have been instrumental in the successful implementation of Lean practices across diverse sectors, offering both strategic insights and actionable improvements.

2.3.1 Value Stream Mapping (VSM)

VSM is a visual tool that maps out the flow of materials, information, and processes necessary to deliver a product or service to a customer. Its primary purpose is to identify and eliminate waste by highlighting non-value-adding activities, bottlenecks, and inefficiencies

(PASQUALINI; ZAWISLAK, 2005). Unlike other Lean tools, VSM offers a comprehensive view of the entire value stream, enabling organizations to pinpoint areas for improvement systematically. In the context of Industry 4.0, VSM is evolving to include real-time data visualization, making it even more powerful for dynamic environments (GIAMPIERI, 2020; GIL-VILDA et al., 2021).

The application of VSM in construction, as detailed by Pasqualini and Zawislak (2005), provides a compelling example of its adaptability. Their study applied VSM to a Brazilian construction company, modifying the tool to suit the sector's unique characteristics, such as its variability and project-based workflows. The authors demonstrated how VSM could streamline construction processes, reduce delays, and enhance alignment between planned and actual workflows (PASQUALINI; ZAWISLAK, 2005).

As an example of a VSM, Pasqualini and Zawislak (2005) described a case where VSM was used to improve the workflow in a construction project. Below, an example of the VSM they developed.

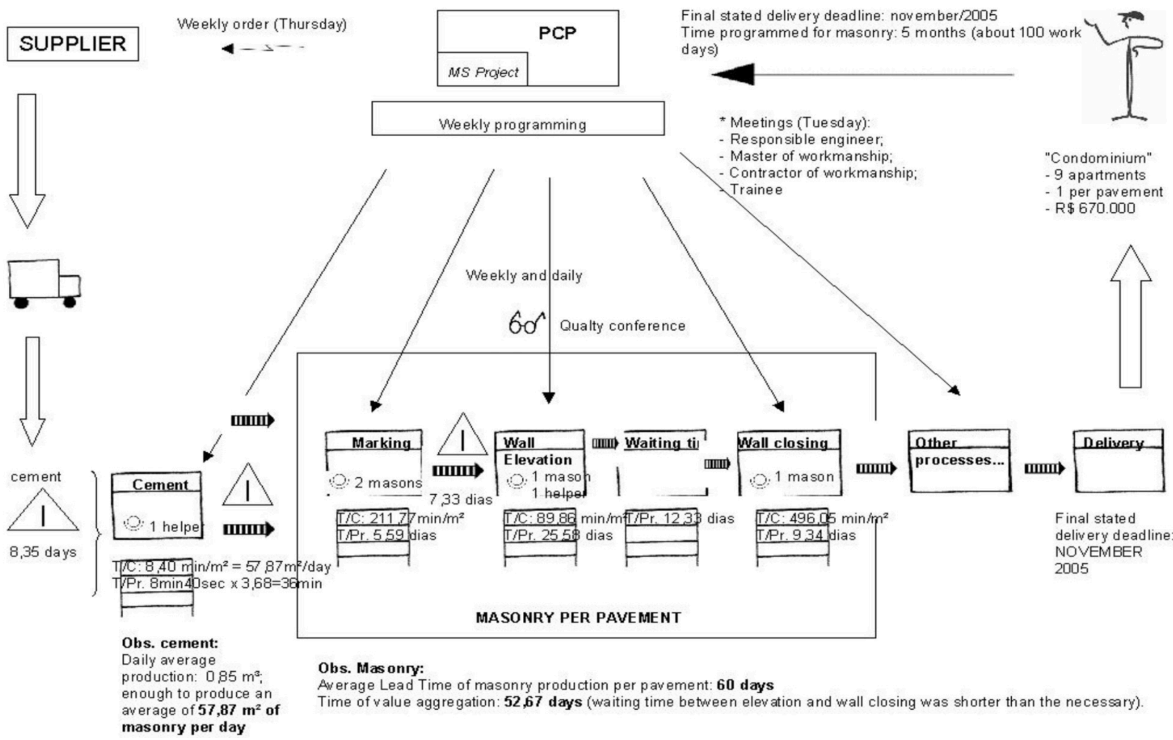


Figure 2: VSM – Example (PASQUALINI; ZAWISLAK, 2005, p. 122)

2.3.2 The 5S Methodology

The 5S methodology focuses on workplace organization and standardization, providing a foundation for other Lean tools and practices. Originating from Japan, the methodology consists of five principles: Seiri (Sort), Seiton (Set in order), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain) (HOHMANN, 2010) (OLIVEIRA et al., 2018). Each step aims to create a clean, efficient, and safe work environment, reducing time spent searching for tools or materials and minimizing errors caused by disorganization.

The 5S methodology has proven particularly valuable in environments where precision and efficiency are critical. For example, in construction, applying 5S principles can lead to better on-site organization, reduced material waste, and enhanced safety (GIL-VILDA et al., 2021). Furthermore, 5S serves as a prerequisite for implementing advanced Lean tools and Industry 4.0 technologies, ensuring that processes are stable and standardized before automation is introduced (GIAMPIERI, 2020).

2.4 Challenges and Adaptability of Lean in Data Management and Industry 4.0

The integration of Lean principles with digital frameworks in Industry 4.0 introduces both transformative opportunities and significant challenges. While Industry 4.0 technologies, such as IoT, artificial intelligence, and big data analytics, provide tools to enhance Lean practices, their implementation often encounters cultural, technical, and organizational barriers. This subsection explores these challenges, as well as Lean's adaptability to data management and its implications for modern industries.

2.4.1 Challenges in Implementing Lean in Industry 4.0

One of the primary challenges of integrating Lean tools with Industry 4.0 is aligning Lean’s human-centric philosophy with the automated, data-driven approach of Industry 4.0. Lean traditionally relies on employee engagement, continuous improvement, and human problem-solving, while Industry 4.0 emphasizes machine learning, real-time data, and automation (PETTERSEN, 2008; GIL-VILDA et al., 2021). This divergence often creates tension, requiring organizations to strike a balance between technological advancements and retaining Lean's human element.

For example, Pasqualini and Zawislak (2005) highlighted the difficulty of implementing digitalized workflows in construction, where variability in project timelines and the involvement of diverse stakeholders complicate standardization (PASQUALINI; ZAWISLAK, 2005). Similarly, in manufacturing, Gil-Vilda et al. (2021) identified challenges such as fragmented data systems and the need for workforce training to interpret and act on real-time analytics effectively (GIL-VILDA et al., 2021).

Another significant barrier is resistance to change, particularly in industries with entrenched processes. Hohmann (2010) emphasized that introducing tools like the 5S methodology or VSM often requires a cultural shift, as employees must adopt new ways of working that prioritize organization and process visualization (HOHMANN, 2010). Moreover, the high costs associated with implementing Industry 4.0 technologies, such as IoT infrastructure or AI algorithms, can deter organizations from fully embracing Lean 4.0 (GIAMPIERI, 2020; MILETIĆ; MILETIĆ, 2017).

2.4.2 Adaptability of Lean in Data Management

Despite these challenges, Lean has demonstrated remarkable adaptability in addressing data management inefficiencies. The integration of Lean tools with digital systems enables organizations to leverage data for process optimization. For instance, Value Stream Mapping (VSM), when combined with real-time data analytics, allows for dynamic adjustments to workflows based on live insights rather than static snapshots. This adaptability is especially critical in sectors with fluctuating demand or complex supply chains (GIAMPIERI, 2020; GIL-VILDA et al., 2021).

An example of Lean's adaptability in data management can be found in the work of Garnier (2010), who applied VSM to pharmaceutical production. By incorporating digital data tracking into VSM, Garnier’s study identified bottlenecks in production and proposed real-time monitoring solutions to enhance efficiency (GARNIER, 2010). Similarly, Oliveira et al. (2018) demonstrated how 5S principles could be applied to organize digital assets, such as data storage systems, ensuring consistency and accessibility across teams (OLIVEIRA et al., 2018).

2.4.3 Opportunities for Lean 4.0 in Industry and Data Management

While challenges remain, the integration of Lean and Industry 4.0 offers significant opportunities for innovation. For instance, predictive maintenance powered by IoT aligns with Lean's focus on minimizing downtime, enabling organizations to preempt equipment failures before they occur (GIL-VILDA et al., 2021; GIAMPIERI, 2020). Additionally, big data analytics enhances Lean's continuous improvement efforts by providing deeper insights into process inefficiencies and customer behavior (MILETIĆ; MILETIĆ, 2017).

In data management, Lean principles encourage the elimination of redundant or low-value data processes. For example, by applying Seiri (Sort) and Seiton (Set in order) from the 5S methodology, organizations can streamline their data systems, ensuring that only relevant and accurate information is accessible to decision-makers (HOHMANN, 2010; OLIVEIRA et al., 2018). This approach not only reduces storage costs but also improves decision-making speed and accuracy.

2.5 The Role of Lean in Enhancing Project Productivity

Lean methodologies have long been associated with improving project productivity by minimizing waste, enhancing workflows, and fostering collaboration. In industries characterized by complexity and variability, such as construction and manufacturing, Lean principles provide a structured approach to identifying inefficiencies and optimizing resource allocation. This subsection explores the practical application of Lean tools in improving project outcomes and their integration with modern technological advancements.

2.5.1 Enhancing Workflow Efficiency

One of Lean's most significant contributions to project productivity lies in its ability to streamline workflows. Tools like Value Stream Mapping (VSM) enable organizations to visualize their processes, identify bottlenecks, and implement targeted improvements. For example, Pasqualini and Zawislak (2005) demonstrated the use of VSM in a Brazilian construction company, where it highlighted inefficiencies in material handling and scheduling. By addressing these issues, the company reduced delays and improved alignment between planned and actual project timelines (PASQUALINI; ZAWISLAK, 2005).

Similarly, Garnier (2010) applied VSM in the pharmaceutical industry, showcasing its effectiveness in reducing lead times and improving coordination between production stages. The ability to adapt VSM to different contexts, whether static production environments or dynamic project-based workflows, underscores its versatility and value in enhancing productivity (GARNIER, 2010).

2.5.2 Fostering Collaboration and Communication

Lean methodologies also emphasize the importance of collaboration and communication, critical factors for successful project management. Tools like Kanban and 5S facilitate transparency and organization, creating environments where teams can work cohesively toward shared goals. Hohmann (2010) highlighted the role of 5S in fostering better workplace organization, reducing time spent searching for tools or information, and minimizing errors caused by disorganization (HOHMANN, 2010). This principle extends to digital collaboration as well, where 5S can be applied to streamline data sharing and standardize communication protocols (OLIVEIRA et al., 2018).

2.5.3 Integration with Industry 4.0 for Enhanced Productivity

The integration of Lean principles with Industry 4.0 technologies further amplifies their impact on project productivity. Tools like IoT and big data analytics provide real-time insights into project performance, enabling dynamic adjustments to workflows and resource allocation. Gil-Vilda et al. (2021) explored this synergy, noting how predictive analytics powered by Industry 4.0 aligns with Lean's focus on reducing downtime and streamlining operations (GIL-VILDA et al., 2021). For instance, predictive maintenance ensures equipment reliability, reducing interruptions and maintaining steady project progress (GIAMPIERI, 2020).

In data-driven environments, Lean principles enhance the effectiveness of digital tools by providing a clear framework for continuous improvement. For example, applying Seiri (Sort) from the 5S methodology helps organizations filter out redundant data, ensuring that decision-makers focus on actionable insights (HOHMANN, 2010; OLIVEIRA et al., 2018). This alignment between Lean and Industry 4.0 demonstrates their combined potential to drive productivity gains across industries.

2.5.4 Overcoming Challenges to Maximize Impact

While Lean methodologies offer significant productivity benefits, their implementation often encounters resistance due to cultural and organizational inertia. For instance, Ughetto (2020) noted that Lean initiatives are sometimes perceived as cost-cutting measures, leading to skepticism among employees and stakeholders (UGHETTO, 2020). To overcome these challenges, organizations must emphasize the long-term value of Lean, both in terms of efficiency gains and its human-centric approach to continuous improvement.

Furthermore, the high cost and complexity of integrating Industry 4.0 technologies into Lean frameworks can pose barriers, particularly for smaller organizations. Pasqualini and Zawislak (2005) underscored the need for tailored approaches that consider sector-specific constraints, such as the variability and fragmentation common in construction (PASQUALINI; ZAWISLAK, 2005).

2.6 Conclusion

The literature demonstrates that Lean methodologies remain a powerful framework for improving organizational efficiency, adaptability, and productivity across diverse industries. From their origins in the Toyota Production System to their integration with Industry 4.0 technologies, Lean principles have evolved to meet the complex demands of modern businesses. The tools at Lean's core, such as Value Stream Mapping (VSM) and the 5S methodology, have shown remarkable versatility, transitioning from manufacturing to sectors such as healthcare, construction, and IT.

The integration of Lean with digital technologies, leading to the emergence of Lean 4.0, offers transformative potential. Industry 4.0 tools, such as IoT, big data analytics, and artificial intelligence, provide organizations with real-time insights and predictive capabilities that enhance traditional Lean processes. For example, VSM is now being enriched with dynamic data visualization, while the 5S methodology is being applied to digital environments to streamline data management and improve decision-making accuracy. These innovations allow organizations to achieve greater agility and responsiveness in highly competitive environments.

However, the implementation of Lean and Lean 4.0 is not without challenges. Resistance to change, cultural inertia, and the high cost of digital tools are common barriers that organizations must overcome. Case studies, such as those presented by Pasqualini and Zawislak (2005) in construction and Garnier (2010) in the pharmaceutical industry, highlight the importance of tailoring Lean practices to sector-specific constraints. The successful adaptation of Lean tools often requires a thoughtful balance between maintaining its human-centric approach and leveraging the automation capabilities of Industry 4.0.

Lean's adaptability is further emphasized in data management, where its principles have been applied to reduce inefficiencies, eliminate redundancies, and create standardized processes. Tools like VSM and 5S have demonstrated their ability to optimize workflows, enhance collaboration, and foster a culture of continuous improvement. These tools, when combined with advanced digital technologies, enable organizations to achieve sustained productivity and operational excellence.

In summary, Lean methodologies continue to evolve, bridging the gap between traditional practices and the demands of Industry 4.0. By addressing implementation challenges and leveraging digital advancements, organizations can unlock the full potential of Lean to drive innovation, efficiency, and competitiveness. Future research should focus on developing frameworks to integrate Lean principles with emerging technologies, ensuring their successful application across even more sectors and environments.

3 METHODOLOGY

3.1 Research Approach

This research adopts a qualitative case study approach to explore the implementation of Lean production methodologies within the construction industry at SNEF Brasil. The case study method is appropriate for investigating complex processes, particularly in real-world settings where variables cannot be easily controlled. This research approach is well-suited for understanding the impact of Lean tools such as VSM and 5S on project management processes, as it allows for a detailed analysis of the company's existing workflows and the identification of inefficiencies.

The primary objective of this research is to evaluate the effects of Lean implementation on improving productivity and reducing waste in construction project management. To achieve this, both observational data from the company's ongoing projects and process flow analysis through Lean tools are employed.

3.2 Data Collection Methods

3.2.1 Observations

A significant portion of the data was collected through extensive direct observations of project workflows at SNEF Brasil. Over a period of a month, daily operations were meticulously monitored to gain an in-depth understanding of the company's processes and cultural dynamics. This hands-on approach enabled the real-time identification of waste—non-value-adding activities—that permeated various aspects of the workflow.

Through these observations, specific inefficiencies such as delays in report generation, prolonged waiting times between sequential tasks, and miscommunication between cross-functional teams were uncovered. For instance, it was noted that reports often faced delays due to redundant approval processes, and teams frequently experienced bottlenecks waiting for inputs from other departments.

The importance of these observational insights cannot be overstated. By being physically present in the operational environment, subtle issues that might have been overlooked by other data collection methods came to light. This immersive method allowed for the capture of nuanced behaviors and practices that contribute to inefficiency. Observational data became a critical foundation for the study, providing empirical evidence of process shortcomings.

Moreover, these firsthand observations were instrumental in pinpointing specific areas where Lean tools could be most effectively applied. They offered a granular level of detail that enriched the analysis, ensuring that recommendations for improvement were both practical and precisely targeted. Without this observational groundwork, the identification of waste and the subsequent implementation of Lean methodologies would lack the necessary depth and accuracy to drive meaningful change.

3.2.2 Interviews with Key Stakeholders

Interviews were conducted with key personnel involved in the project management process, including project managers, site supervisors, and construction workers. At SNEF Brasil, each project is markedly different—varying in duration, budget, and workforce composition—which presents unique challenges and demands. These interviews were instrumental in capturing the nuances of these diverse projects, providing valuable insights into both universal and specific operational issues.

Through these in-depth conversations, we gained a comprehensive understanding of:

- **Task Coordination and Management:** How tasks were organized and executed across projects with differing scopes and complexities.
- **Common Sources of Delays and Bottlenecks:** Despite the diversity of projects, certain inefficiencies were consistently observed, such as communication gaps, highlighting general areas for improvement.
- **Current Practices Affecting Workflow Efficiency:** Identifying which existing procedures supported efficient operations and which hindered them, offering a baseline for enhancement.

The diversity of projects emphasized the need to identify general bottlenecks that affected all operations, leading to the development of universal tools and strategies to mitigate these issues. This approach enabled the creation of solutions that could be applied broadly across different projects, enhancing overall efficiency.

Simultaneously, the interviews highlighted the importance of addressing specific project demands. The unique challenges of each project underscored the necessity for continuous improvement and adaptability—the core principles of kaizen. This mindset encourages ongoing refinement and responsiveness to the distinct needs of each project, ensuring that the Lean interventions are not only effective but also flexible.

The interview data were essential for understanding the cultural and operational barriers to Lean implementation at SNEF Brasil. They informed the tailoring of the Value Stream Mapping (VSM) and 5S interventions to be both universally applicable and adaptable to specific project contexts. By bridging the gap between general efficiency improvements and project-specific needs, the interviews facilitated a holistic approach to implementing Lean methodologies within the organization.

3.2.3 Document Analysis

Documents such as project schedules, reports, and technical documentation were reviewed to understand the structure of the company's project management processes. Analyzing these documents allowed me to map out the value stream and identify specific areas where time and resources were being wasted.

3.3 Analysis Techniques

After completing data collection (observations, interviews and document analysis), the following analysis techniques were employed:

3.3.1 Value Stream Mapping (VSM)

The first analysis technique employed in this study was Value Stream Mapping (VSM), a core Lean tool designed to visualize the flow of materials, information, and activities within a process. The purpose of using VSM in this research was to identify non-value-adding activities, streamline workflows, and propose targeted improvements in the data treatment processes at SNEF Brasil.

Given the diversity of the audience who would later analyze and act upon the VSM results, a decision was made to simplify the traditional VSM methodology. Instead of presenting a detailed, textbook-style map, the VSM was adapted to focus on visualizing the complexity of the data treatment process without overwhelming stakeholders with excessive details. This simplified VSM included only the most critical elements necessary to map and understand the data journey, making it accessible to everyone, from construction workers to executive stakeholders.

A key feature of the adapted VSM was the integration of an Excel spreadsheet to represent the time spent at each stage of the data treatment process. This spreadsheet provided a clear and quantifiable visualization of delays, bottlenecks, and inefficiencies, offering stakeholders an intuitive understanding of where improvements were needed. By using Excel as a supplement to the VSM, the data became more tangible and relatable, fostering a greater connection between abstract process concepts and real-world operations.

The simplified VSM proved to be highly effective in achieving its goal of fostering a shared understanding of the data treatment workflow. It visually mapped out all the steps involved, from initial data collection at the construction site to the generation of production reports for stakeholders. This approach helped bridge the gap between operational staff on the ground and decision-makers at higher levels, ensuring that all parties could comprehend the intricacies of the process without becoming overwhelmed by technical jargon or excessive information.

By tailoring the VSM to the needs of the audience, the research ensured that the tool not only highlighted inefficiencies but also facilitated productive discussions among stakeholders. The visual representation enabled everyone to see how information moved through the organization, revealing areas where delays and miscommunications occurred. This shared understanding provided the foundation for collaborative efforts to address inefficiencies and improve overall project productivity.

In summary, the adapted VSM served as a crucial tool for mapping and visualizing the data treatment process at SNEF Brasil. By prioritizing simplicity and clarity, the research successfully communicated the complexity of the workflow to a diverse audience, ensuring alignment and engagement across all levels of the organization. This approach highlighted the importance of tailoring Lean tools to the specific context and needs of their application, ultimately driving meaningful and actionable insights.

3.3.2 5S Methodology

Building upon the bottlenecks identified through the Value Stream Mapping (VSM), the second Lean tool applied was the 5S methodology. This approach aimed to improve the organization and standardization of the data processing workflow between the construction site and the analyzing team by directly addressing the inefficiencies uncovered.

The five steps—Sort, Set in Order, Shine, Standardize, and Sustain—were systematically applied to the specific activities causing bottlenecks to enhance productivity:

- **Sort:** I began by thoroughly reviewing all data collected from the construction site. This step involved eliminating unnecessary or redundant information to ensure that only relevant and accurate data was forwarded to the analyzing team. By filtering out irrelevant data, we reduced the clutter that often led to confusion and errors.
- **Set in Order:** The remaining data was organized in a logical and consistent manner. I established clear protocols for data formatting, naming conventions, and storage locations. This made it easier for the analyzing team to access and process the data efficiently, reducing time spent searching for information and minimizing the risk of misinterpretation.
- **Shine:** Regular audits and cleaning processes were implemented to maintain the integrity of the data. This step ensured that the data was clear, up-to-date, and ready to be treated at any given time. By keeping the data "shining," I enhanced its reliability and the overall efficiency of data handling.
- **Standardize:** I developed standardized procedures for data collection, communication protocols, and data handling between the construction site and the analyzing team. This included creating templates for data entry, establishing regular communication schedules, and defining roles and responsibilities. Standardization eliminated variability and confusion, ensuring consistency across all projects.
- **Sustain:** To maintain these improvements over time, I put in place mechanisms for continuous monitoring and feedback. Training sessions were conducted to educate staff on the new processes, and performance metrics were established to track adherence to the 5S practices. This step ensured that the gains in efficiency and organization were not temporary but became part of the organizational culture.

By applying the 5S methodology to these specific bottlenecks, we created a more disciplined and efficient data treatment workflow. This targeted application not only improved workflow efficiency and reduced the potential for errors in critical areas but also had a positive impact on overall project productivity. The enhanced clarity and readiness of the data enabled quicker decision-making and more effective analysis.

Furthermore, organizing the communication tools by making them clearer and more efficient bridged the gap between the construction site and the analyzing team. This improvement ensured that information flowed seamlessly, reducing delays caused by miscommunication or lack of timely data transfer.

By fostering an organized and standardized data processing environment, the 5S methodology complemented the insights gained from the VSM. Together, they led to more cohesive and efficient project management practices, addressing both the physical flow of materials and the informational flow critical to project success.

This comprehensive approach not only tackled the immediate inefficiencies but also embedded a culture of continuous improvement and adaptability within the organization. It highlighted the importance of meticulous data management and effective communication as foundational elements for Lean implementation at SNEF Brasil.

3.4 Tools Used in Data Analysis

To effectively analyze the company's historical project performance data and develop new analytical tools, Microsoft Excel combined with Visual Basic for Applications (VBA) automation was employed. This combination was chosen for its versatility, user-friendly interface, and ability to handle complex data manipulation tasks essential for the project's needs.

The Development Process

The development process was a critical component of this study, involving several key steps to transform raw data into actionable insights. By focusing on creating customized tools within Excel and utilizing VBA automation, the study directly addressed the inefficiencies in data processing and communication identified during observations and interviews.

Data Collection and Preparation

- **Gathering Data:** Raw data was collected from multiple sources, including time logs, project schedules, resource allocation sheets, and communication records between the construction site and the analyzing team. This comprehensive data collection ensured that all relevant information was available for thorough analysis.
- **Data Cleaning:** The collected data often contained inconsistencies, errors, and gaps. Excel functions and VBA scripts were employed to clean and standardize the data, ensuring accuracy and reliability. This step was crucial to prevent errors in subsequent analyses and to maintain the integrity of the findings.
- **Structuring Data:** Organized data structures were established within Excel, such as tables and relational databases, to facilitate efficient analysis. Proper data structuring allowed for easier manipulation, querying, and retrieval of information.

Tool Development with VBA Automation

- **Creating Automated Spreadsheets:** Customized Excel spreadsheets with embedded VBA macros were developed to automate repetitive tasks. This included automating data imports, performing calculations, generating reports, and updating data visualizations. Automation reduced manual workload and minimized the potential for human error.

- **Developing Analytical Functions:** Advanced VBA scripts were written to perform complex calculations required for the analysis. This included tracking the time taken to complete various tasks, calculating productivity levels, and identifying key performance metrics that required improvement. These analytical functions provided deeper insights into project performance and efficiency.

Benefits Realized

By employing Excel and VBA automation in this manner, several benefits were realized:

- **Enhanced Efficiency:** Automation significantly reduced manual data entry and processing time. Team members could focus on more strategic tasks, such as analysis and decision-making, rather than routine data handling.
- **Improved Accuracy:** Automated calculations and data validations minimized errors, increasing the reliability of the data and the insights derived from it. This improved confidence in the findings and recommendations.
- **Standardization of Processes:** The development of these tools led to the standardization of data collection and reporting processes. Consistent formats and protocols eliminated variability and confusion, streamlining communication between the construction site and the analyzing team.
- **Facilitation of Lean Interventions Assessment:** The tools provided the means to quantitatively assess the success of Lean interventions. By analyzing performance metrics before and after implementation, concrete evidence of improvements—such as reduced lead times and increased productivity levels—was obtained.

The use of Excel and VBA automation was integral to the project's success. By focusing on creating automated, efficient, and user-friendly tools, the study directly addressed the inefficiencies in data processing and communication identified earlier. This not only enhanced productivity but also fostered a culture of continuous improvement and data-driven decision-making within SNEF Brasil. The tools served as a vital link between the construction site and the analyzing team, ensuring that accurate, timely, and actionable information was always available to drive project success.

3.5 Implementation of Lean Tools

3.5.1 VSM Implementation Process

After creating the current-state map through VSM, the following steps were taken to implement the proposed improvements:

- **Meetings with Key Stakeholders:** To ensure alignment and buy-in, the future-state map and proposed tools were presented to key personnel, including project managers, site supervisors, and department heads. These meetings facilitated open discussions, allowing stakeholders to provide feedback, express concerns, and suggest modifications. Their input was invaluable in refining the action plan to be both practical and effective.
- **Action Plan Development:** Based on the VSM analysis and stakeholder feedback, a comprehensive action plan was developed. This plan outlined specific steps required to eliminate inefficiencies, such as reassigning resources, modifying communication protocols, and adjusting workflow sequences. Responsibilities were assigned, timelines were established, and measurable objectives were set to track progress.
- **Implementation of Changes:** The action plan was executed in a phased manner to minimize disruption. Changes to processes were communicated clearly to all team members, with training provided where necessary. For example, new communication channels were established to streamline data flow between the construction site and the analyzing team.
- **Results Evaluation:** Key performance indicators identified during the analysis phase were tracked to evaluate the effectiveness of the VSM implementation. Metrics such as lead times, waiting times, and communication efficiency were measured before and after the implementation to quantify improvements.

3.5.2 5S Implementation Process

The 5S methodology was applied in stages to systematically improve the organization and standardization of the data processing workflow and communication between the construction site and the analyzing team. The implementation process included the following steps:

- **Initial Sorting (Seiri):** Unnecessary items and redundant data were identified and removed from the data process. This step reduced clutter, minimized mistakes caused by outdated or irrelevant information, and facilitated clearer communication.
- **Organization (Seiton):** Tools and materials used in data processing were reorganized for optimal efficiency. Clear labeling and designated digital storage areas were established for data files, templates, and communication records. This organization made it easier for team members to find and access the necessary resources quickly.
- **Shining and Cleaning (Seiso):** Regular maintenance schedules were introduced to ensure that the data processing environment remained tidy and efficient. This included routine checks for data accuracy, updates to templates, and cleaning up of outdated files. Maintaining a "clean" data environment improved overall data quality and reliability.
- **Standardization (Seiketsu):** Procedures for data communication and processing were standardized to reduce variability and confusion. Standard templates for data entry, reporting formats, and communication protocols were established. This consistency ensured that all team members were aligned in their practices, reducing errors and improving efficiency.
- **Sustaining (Shitsuke):** To ensure that the improvements were maintained over time, regular audits and reviews were instituted. Training sessions reinforced the importance of adhering to the 5S practices, and performance metrics were monitored to track compliance. This step fostered a culture of discipline and continuous improvement.

3.5.3 Integration of VSM and 5S

The combined implementation of VSM and the 5S methodology created a synergistic effect on improving project management practices. While VSM provided a macro-level view of the processes and identified bottlenecks, the 5S methodology addressed the micro-level organizational aspects that directly impacted daily operations. Together, they:

- **Enhanced Communication Efficiency:** Improved the flow of information between the construction site and the analyzing team, reducing delays caused by miscommunication.

- **Reduced Lead Times and Waiting Periods:** Streamlined processes led to faster completion of tasks and reduced idle times.
- **Improved Data Accuracy and Reliability:** Standardized data handling minimized errors and inconsistencies.
- **Fostered a Culture of Continuous Improvement:** Encouraged ongoing evaluation and adaptation of processes to meet evolving project demands.

3.6 Limitations of the Study

Despite the positive outcomes achieved, the study faced several limitations that should be acknowledged:

- **Cultural Resistance:** Some employees exhibited resistance to the changes introduced through Lean implementation. This was particularly evident in the adoption of new work habits and adherence to standardized processes. Overcoming entrenched behaviors required additional training and change management efforts, which extended the implementation timeline.
- **Time Constraints:** The time available to fully implement and evaluate the effects of the Lean methodologies was limited. This constraint may have affected the depth of the analysis and the ability to observe long-term impacts of the changes. A longer evaluation period would provide a more comprehensive understanding of the sustainability of the improvements.
- **Limited Access to Historical Data:** Certain older projects lacked complete data, which restricted the ability to perform a thorough analysis of past performance. This limitation impacted the baseline measurements and may have influenced the assessment of improvements. Efforts were made to supplement missing data where possible, but some gaps remained.
- **Variability Among Projects:** Each project at SNEF Brasil varies significantly in terms of duration, budget, and workforce composition. This diversity made it challenging to generalize findings across all projects. While general bottlenecks were identified, specific project demands required tailored solutions, emphasizing the need for continuous improvement and adaptability.
- **Resource Limitations:** The implementation required resources in terms of time, personnel, and technology. Balancing these demands with ongoing project commitments was a challenge, and resource constraints may have limited the extent of the interventions.

3.7 Conclusion

In this chapter, the methodology employed in this study was detailed, encompassing data collection methods, analysis techniques, and the application of specific Lean tools. The combination of observations, interviews, and data analysis tools like Excel and VBA automation provided a robust foundation for understanding the inefficiencies within SNEF Brasil's project management processes.

The implementation of Value Stream Mapping and the 5S methodology offered a structured approach to identifying and addressing these inefficiencies. By mapping the current and future states of processes and systematically organizing and standardizing data workflows, significant improvements in productivity and efficiency were achieved.

While the study faced limitations such as cultural resistance, time constraints, and data availability issues, the positive impacts of the Lean interventions were evident. The methodologies not only enhanced current operations but also instilled a culture of continuous improvement and adaptability, essential for the organization's future success.

The findings and experiences from this study provide valuable insights for SNEF Brasil and similar organizations seeking to implement Lean methodologies in project management. The next chapters will delve deeper into the analysis of results and discuss recommendations for sustaining and expanding upon these improvements.

4 COMPANY BACKGROUND AND PROCESS ANALYSIS

4.1 Company Overview: SNEF Brasil

Due to confidentiality agreements and the public nature of the company's clients, specific insights into the company cannot be provided. As a result, the presentation of tools and methodologies will be general and may be intentionally blurred to protect sensitive information.

SNEF Brasil is a subsidiary of the international SNEF Group, which specializes in delivering technological solutions and engineering services across various industries, including energy, infrastructure, and industrial projects. The company operates as a project integrator, with a focus on managing complex construction projects through cutting-edge engineering and skilled labor.

SNEF Brasil has made significant contributions to Brazil's infrastructure, playing a key role in projects such as the São Paulo Metro Line 4 and Metro Line 15, which involved the installation of complex systems like SCADA, ventilation, CCTV, and energy distribution. The company's expertise lies in its ability to deliver high-quality, efficient project management solutions that meet stringent client requirements.

Despite its success, SNEF Brasil faced challenges in managing the workflow and productivity of its data process, which led to the decision to implement Lean production methodologies to address inefficiencies and improve overall performance.

4.2 Overview of Pre-Lean Project Management Processes

Before the introduction of Lean methodologies, SNEF Brasil's project management processes were predominantly characterized by manual data collection, fragmented workflows, and a lack of standardization. The company's primary tools for tracking progress and productivity were the Relatórios Diários de Campo (RDCs), Relatórios Diários de Obras (RDOs), and Histograms. While these tools provided some level of insight into project activities, they were prone to inefficiencies and waste due to their manual implementation and isolated usage.

Manual Data Collection and Fragmented Workflows

Data collection is conducted manually on-site, with field workers recording information on paper forms or spreadsheets. This data was then physically transported or electronically sent to various departments for processing. The absence of a centralized system led to siloed information, making it difficult to obtain a comprehensive view of project status. Delays were common, as data had to pass through multiple hands before reaching decision-makers, resulting in outdated information being used for critical decisions.

Inefficiencies in Tracking Tools

- **Relatórios Diários de Campo (RDCs):** These daily field reports were intended to capture on-site activities and progress. However, due to their manual nature, they were susceptible to delays in submission and data inaccuracies.
- **Histograms:** Used to visualize data such as resource allocation over time, histograms were often outdated by the time they were compiled and reviewed. The manual process of creating these charts consumed valuable time and resources.

Development of the Value Stream Map (VSM)

To gain a deeper understanding of the existing project management processes and to identify areas ripe for improvement, I developed a simplified Value Stream Map (VSM) of the company's data flow within a project (as explained in the Methodology chapter – 3.3.1). The VSM illustrated the complete data journey, starting from the initial collection at the construction site to the final generation of reports for stakeholders. It mapped out each step.

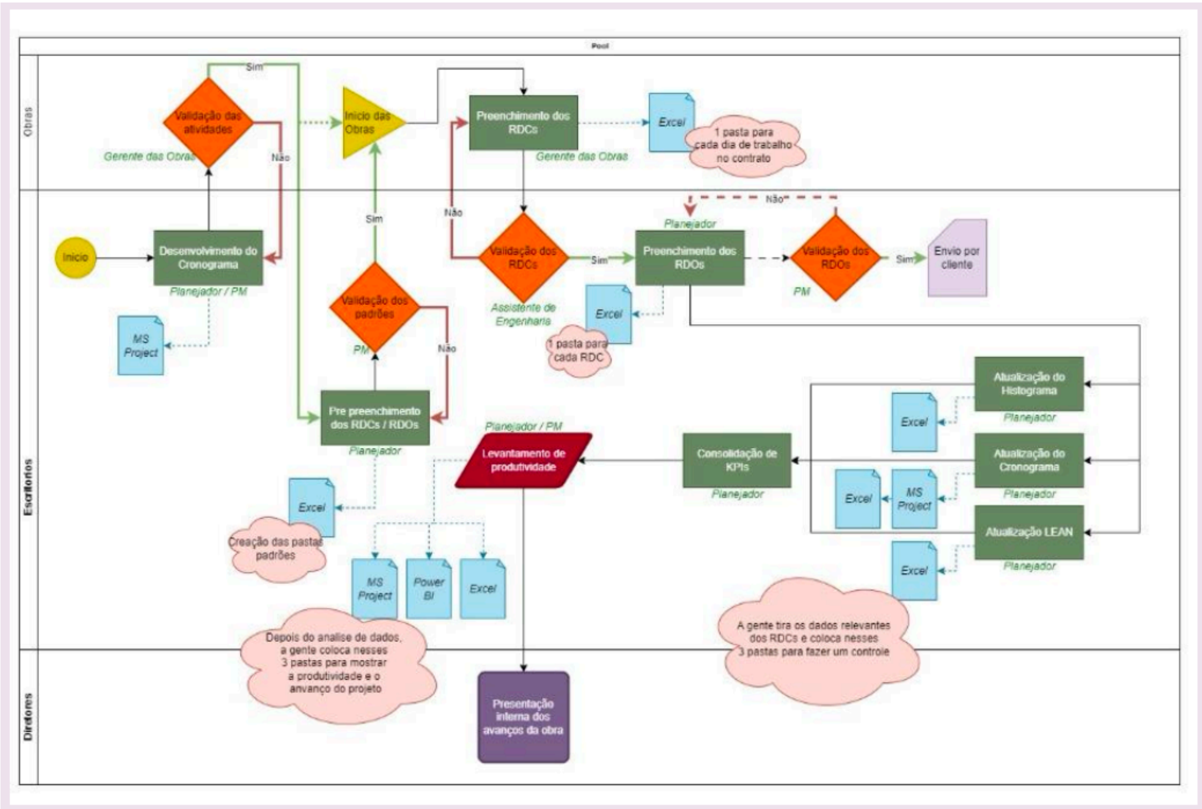


Figure 3: VSM Data Journey

As detailed in the methodology chapter, I dedicated over a month to an in-depth analysis of the project processes. This comprehensive examination enabled me to establish a general timeline for each activity within the Value Stream Map (VSM), culminating in the creation of a detailed table. My key performance indicator (KPI) was the time required for each activity, measured in business days. Hence, my objective was the Lead Time of the Data Journey.

To accurately determine the time for each activity and ensure the reliability of the KPI data, I conducted a comparative analysis across three projects of varying sizes and complexities:

- **Small-Sized Project**: A six-month duration project with a small budget and a limited workload.
- **Medium-Sized Project**: A project of moderate scale, serving as a middle ground in terms of budget and workload.
- **Large-Sized Project**: A comprehensive project spanning five years, characterized by a heavy workload and a substantial budget.

By analyzing these diverse projects, I was able to identify consistent patterns and average time frames for each activity, regardless of the project's scale. This comparative approach enhanced the robustness and generalizability of the KPI data, allowing for more accurate benchmarking and performance assessment.

The analysis revealed that the activities associated with the Relatórios Diários de Campo (RDCs) consumed the most time across all projects. Specifically, these activities were the most time-intensive due to their manual nature and the inefficiencies previously identified. Furthermore, it was observed that the analyzing team spent more than four business days on data processing for each project, highlighting a significant area for potential improvement.

This comprehensive approach to data collection and analysis provided reliable KPI data that underscored the need for process enhancements, particularly concerning the RDCs. The findings served as a critical foundation for implementing Lean methodologies aimed at reducing time consumption, eliminating waste, and improving overall project efficiency.

Activity	**Responsible**	**Feb-24**
Start		0.00
Development of Schedule	Planner / PM	5.00
Validation of Activities	Field Supervisor	5.00
Pre-filling of RDCs / RDOs	Planner	0.50
Validation of Standards	PM	0.50
Start of Construction		
Filling out RDCs	Field Supervisor	0.10
Sending RDCs	Field Supervisor	7.00
Data Processing and Analysis Activities:		
Validation of RDCs	*Engineering Assistant*	*0.20*
Filling out RDOs	*Planner*	*0.50*

Validation of RDOs / Sending to Client	*PM*	*0.30*
Updating Histogram	*Planner*	*0.80*
Updating Schedule	*Planner*	*0.80*
Updating Lean Metrics	*Planner*	*0.80*
Consolidation of KPIs	*Planner*	*0.80*
Productivity Assessment	Planner / PM	0.50
Internal Presentation of Project Progress	Planner / PM	0.00
Total Time		**22.80**

Table 2: General Time Analysis per Activity in Data Treatment (in business days)

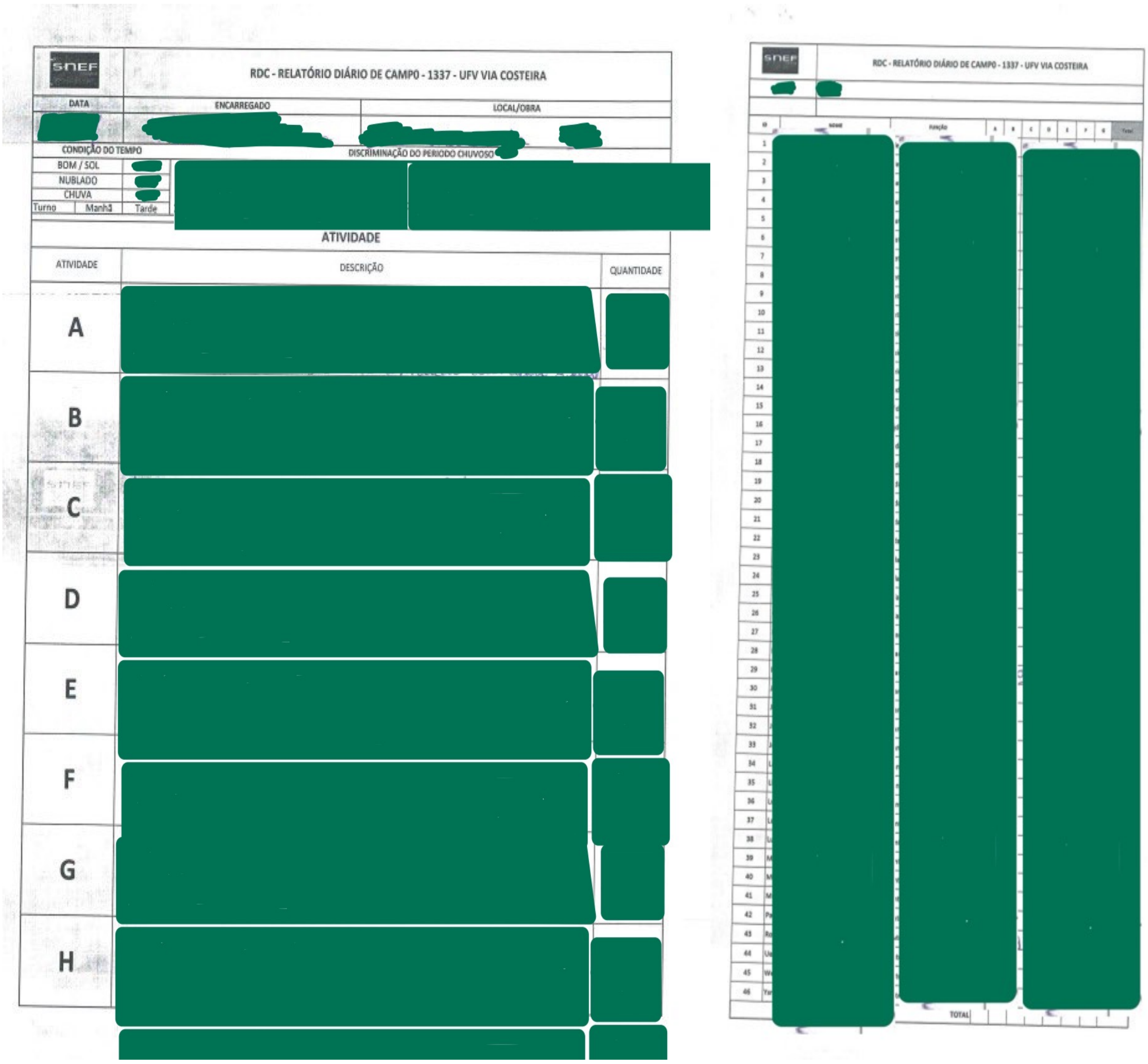
In Italic, the activities of data treatment: Total – 4,2 business days per project

The Value Stream Map (VSM) clearly demonstrates that the Relatório Diário de Campo (RDC) is the sole link between the on-site construction activities and the headquarters, but also as shown by the KPI, the point of waste in the data process. This tool serves as the primary conduit for data communication used in generating reports. Consequently, the RDC emerges as the initial bottleneck in the data processing workflow, as any inefficiencies or delays associated with it directly impact the entire reporting process.

4.2.1 Relatórios Diários de Campo (RDCs)

Relatórios Diários de Campo (RDCs), or Daily Field Reports, were the primary tool used by construction teams to record the daily activities taking place on-site. The RDCs were typically filled out manually by field supervisors, who noted down the progress of various tasks, materials used, and the number of workers on-site. The information captured in these reports was essential for tracking the physical progress of the project.

Upon my arrival, the existing process was structured as follows: the construction manager was responsible for completing two separate paper forms. The first form required the manager to write detailed descriptions of the activities performed on-site. The second form involved listing the team members working on the project and allocating the hours worked per worker for each specific activity.



RDC - RELATÓRIO DIÁRIO DE CAMPO - 1337 - UFV VIA COSTEIRA

DATA	ENCARREGADO	LOCAL/OBRA
[redacted]	[redacted]	[redacted]

CONDIÇÃO DO TEMPO		DISCRIMINAÇÃO DO PERÍODO CHUVOSO
BOM / SOL	[redacted]	[redacted]
NUBLADO	[redacted]	
CHUVA	[redacted]	
Turno Manhã	Tarde	

ATIVIDADE

ATIVIDADE	DESCRIÇÃO	QUANTIDADE
A	[redacted]	[redacted]
B	[redacted]	[redacted]
C	[redacted]	[redacted]
D	[redacted]	[redacted]
E	[redacted]	[redacted]
F	[redacted]	[redacted]
G	[redacted]	[redacted]
H	[redacted]	[redacted]

RDC - RELATÓRIO DIÁRIO DE CAMPO - 1337 - UFV VIA COSTEIRA

[redacted]

NOME | FUNÇÃO

[redacted]

TOTAL

Figure 4: RDC Example

However, before Lean implementation, the RDC process had several inefficiencies:

- **Time delays**: The completion and submission of RDCs often lagged behind actual site activities, sometimes by several days. This delay in data entry affected decision-making, as managers were working with outdated information.
- **Manual errors**: Since the RDCs were filled out manually, errors in reporting were common, such as incorrect task descriptions, incorrect worker names or inaccurate time tracking.
- **Inconsistent reporting**: The lack of standardization in how activities were recorded made it difficult to compare data across different sites or teams (for example linking the activity in the RDC with the activities in the Chronogram). Some workers used different terms for the same activities, complicating project analysis.

- **Reading difficulties**: As it was physically written, it was difficult to read some handwriting, hence analyse the data.
- **Physical Movement of Documents:** Moving paper forms from the construction site to the office introduces unnecessary transportation, increasing the risk of loss or damage.

These inefficiencies led to wasted time, inaccurate data, and delays in responding to problems on the construction site, which in turn affected the overall productivity of the project.

As depicted in the Value Stream Map (VSM), the Relatório Diário de Obras (RDO) is directly connected to the Relatório Diário de Campo (RDC). Both documents share the same purpose: to describe daily activities on the construction site. Consequently, if the RDC contains inaccuracies, these will directly affect the RDO. The planner completes the RDO to ensure that the activities described and the information provided precisely match the contractual stipulations before sending it to the client.

4.2.2 Histogram

The Histogram is a graphical representation of the workforce distribution over time in relation to the project's activities. In SNEF Brasil, histograms were used to visualize the allocation of labor across different tasks and stages of the project.

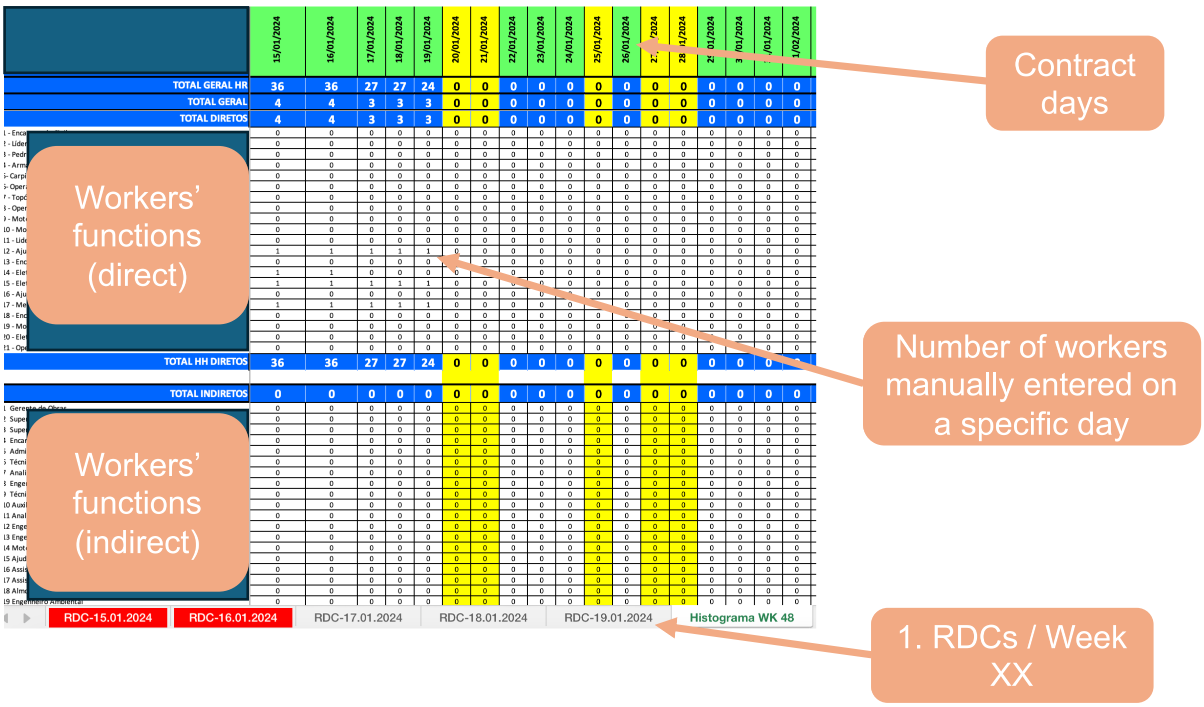


Figure 5: Histogram Example (with indications)

Before the implementation of Lean methodologies, the use of histograms in the project management process exhibited several significant issues:

1. **Manual Updates and Data Entry Errors**
    - **Reliance on Manual Data Entry:** The histograms were updated manually, depending entirely on data collected from the Relatórios Diários de Campo (RDCs). Since these reports were prone to delays and errors due to their paper-based nature, the histograms often contained inaccurate or outdated information.
    - **Lack of Automation:** The physical format of the RDCs meant that no automation was possible in updating the histograms. Every data point had to be entered manually, increasing the risk of human error and consuming valuable time.
    - **Error-Prone Processes:** Manual updates required meticulous attention to detail, such as verifying color codes and entering dates in specific formats. This not only slowed down the process but also led to frequent errors in analyzing productivity metrics and hours worked.
2. **Inconsistent and Inadequate Analysis**
    - **Limited Insight into Labor Utilization:** The histograms primarily displayed the number of workers on-site but lacked detailed analysis of how labor was being utilized. It was difficult to determine whether workers were deployed efficiently or if there were periods of idle time due to waiting for materials or equipment.
    - **Vague Activity Descriptions:** Due to the lack of detailed activity descriptions in the RDCs, the histograms could not provide meaningful insights into workforce productivity or identify specific areas for improvement.
3. **Fragmented Communication and Integration Issues**
    - **Isolation from Project Management Systems:** The histograms were not fully integrated into the broader project management system. This fragmentation meant that data on workforce allocation was not effectively communicated to teams responsible for planning and scheduling.
    - **Suboptimal Resource Allocation:** The lack of effective communication led to suboptimal resource allocation, as planning and scheduling teams did not have accurate or timely information to make informed decisions.
4. **Excessive Manual Effort and Waste**
    - **Absence of Functional Features:** The histograms lacked built-in functions, requiring manual entry for all data, including dates and formatting. Pulling forward dates necessitated entering them manually due to specific format requirements.

- **Increased Potential for Errors:** The manual nature of the work increased the likelihood of errors, such as incorrect data entries and misinterpretation of color codes. These errors impacted the accuracy of productivity analyses and tracking of hours worked.
- **Inefficient Use of Time and Resources:** The extensive manual effort required represented a significant waste of time and resources. Employees spent considerable time on tasks that could have been automated, diverting attention from more value-adding activities.

The lack of real-time data and effective use of histograms meant that workforce management was reactive rather than proactive, often resulting in delays and inefficient use of labor.

4.3 Analysis of Pre-Lean Inefficiencies

The examination of SNEF Brasil's pre-Lean project management processes uncovered several critical inefficiencies that adversely affected productivity and communication. The reliance on manual data collection methods, such as paper-based Relatórios Diários de Campo (RDCs) and manually updated Histograms, introduced significant delays, errors, and resource wastage into the workflow.

Key Inefficiencies Identified:

1. **Delays in Data Transmission and Processing:**
    - **Time Lag in Reporting:** The manual completion and submission of RDCs often lagged behind actual on-site activities by several days. This delay meant that managers and decision-makers were operating with outdated information, impairing timely and informed decision-making.
    - **Physical Movement of Documents:** The necessity to physically transport paper forms from the construction site to the office added unnecessary delays and increased the risk of loss or damage to critical data.
2. **Data Inaccuracies and Inconsistencies:**
    - **Manual Entry Errors:** The manual nature of data entry led to common errors, such as incorrect task descriptions, misrecorded worker names, and inaccurate time tracking.
    - **Lack of Standardization:** Inconsistent reporting due to varied terminology and formats made it difficult to compare data across different sites or teams. This

lack of standardization complicated project analysis and hindered effective communication.

- **Unreadable Handwriting:** Handwritten reports sometimes suffered from legibility issues, making data interpretation and analysis challenging.

3. **Inefficient Use of Resources:**

- **Excessive Manual Effort:** The manual updating of Histograms required meticulous attention to detail, such as verifying color codes and entering dates in specific formats. This consumed valuable time that could have been allocated to more strategic tasks.

- **Potential for Errors:** The absence of built-in functions and automation in the Histograms increased the likelihood of errors in data entry and analysis, impacting the accuracy of productivity metrics and hours worked.

4. **Fragmented Communication and Siloed Information:**

- **Isolation from Project Management Systems:** The Histograms and RDCs were not fully integrated into a centralized project management system. This fragmentation led to siloed information, making it challenging to obtain a comprehensive view of project status.

- **Suboptimal Resource Allocation:** Ineffective communication of workforce allocation data resulted in planning and scheduling teams lacking accurate or timely information, leading to suboptimal resource deployment.

5. **Limited Analytical Insight:**

- **Inadequate Labor Utilization Analysis:** The Histograms primarily displayed the number of workers on-site without providing detailed insights into how labor was being utilized. This limitation made it difficult to identify inefficiencies such as idle time or resource bottlenecks.

- **Vague Activity Descriptions:** The lack of detailed and standardized activity descriptions in the RDCs hindered meaningful analysis and the ability to identify specific areas for improvement.

Impact on Project Performance:

These inefficiencies collectively led to delays in project timelines, increased operational costs due to rework and misallocation of resources, and diminished overall productivity. The dependence on outdated and inaccurate information impaired decision-making processes, while the lack of standardization and automation hindered the company's ability to respond swiftly to on-site issues and adapt to changing project demands.

The identification of the Relatório Diário de Campo (RDC) as the initial bottleneck in the data processing workflow was particularly significant. Since the RDC served as the sole link between on-site activities and headquarters, any inefficiencies or delays associated with it had a cascading effect on the entire reporting process, including the accuracy of the Relatório Diário de Obras (RDO) and the usefulness of the Histograms.

4.4 Conclusion

The comprehensive analysis of SNEF Brasil's pre-Lean project management processes illuminated substantial inefficiencies rooted in manual data collection, fragmented workflows, and a lack of standardization. The critical examination of tools such as the RDCs and Histograms revealed that these traditional methods were not only time-consuming but also prone to errors and miscommunication.

By mapping out the data flow through the development of the Value Stream Map (VSM), the company was able to visualize the entire process and identify primary bottlenecks, notably the RDCs. This visualization was instrumental in understanding how delays and inaccuracies at the initial stages of data collection permeated through to affect overall project performance.

Recognizing these challenges underscored the urgent need for SNEF Brasil to adopt Lean methodologies aimed at streamlining processes, enhancing data accuracy, and improving communication across all teams involved. Addressing these inefficiencies was essential not only for improving current project outcomes but also for positioning the company to better meet stringent client requirements and remain competitive in the industry.

The insights gained from this analysis set the foundation for the subsequent implementation of Lean tools and strategies. By targeting the identified areas of waste and inefficiency, the company aimed to transform its project management practices, leading to improved productivity, reduced costs, and enhanced ability to deliver high-quality solutions. The next chapter will delve into the specifics of how Lean methodologies were implemented and the results achieved through this transformation.

5 LEAN IMPLEMENTATION AND RESULTS

5.1 Introduction

Building upon the comprehensive analysis of pre-Lean inefficiencies detailed in Chapter 4, this chapter delves into the implementation of Lean methodologies at SNEF Brasil and the tangible results achieved. The identified inefficiencies—ranging from manual data entry errors and fragmented workflows to delays in data transmission—highlighted the urgent need for a systematic overhaul of the company's project management processes.

As outlined in Chapter 3: Methodology, the implementation of Lean tools was approached through a structured and iterative process. The first step involved developing new tools designed to address the specific bottlenecks and waste identified in the Value Stream Map (VSM). These tools were not immediately deployed organization-wide; instead, they underwent rigorous testing within our team. This internal testing phase was crucial for several reasons:

- **Spotting Inconsistencies:** By simulating real-world scenarios and workflows, we were able to identify and rectify inconsistencies, errors, or shortcomings in the tools' design and functionality. This ensured that the tools were robust and capable of handling the complexities of actual project environments.
- **Enhancing Usability:** Feedback from team members during the testing phase allowed for refinements that improved the user interface and overall usability of the tools. This step was essential to facilitate smooth adoption by end-users who might be unfamiliar with new technologies or processes.

Following successful internal testing, the refined tools were presented to a project manager for further evaluation. This intermediary step served to:

- **Gain Managerial Insight:** The project manager provided practical insights based on frontline experience, highlighting any potential issues that were not apparent during internal testing.
- **Build Support from Leadership:** Involving management early in the process helped secure buy-in from key stakeholders, which is critical for the successful implementation of any organizational change.

Before full-scale deployment, the tools were then tested on-site with the construction manager. This step was particularly important because:

- **Addressing Resistance to Change:** The construction manager represented the frontline staff who would be directly using the new tools. By presenting a thoroughly tested and refined product, we were able to alleviate concerns and reduce resistance from those hesitant to alter established workflows.

- **Real-World Validation:** On-site testing provided an opportunity to validate the effectiveness of the tools in the actual working environment, ensuring that they met the practical needs of daily operations.

This meticulous approach to tool development and implementation was essential for fostering acceptance and ensuring the sustainability of the Lean initiatives. By engaging multiple layers of the organization—from the internal team to management and on-site staff—we created a collaborative environment conducive to change.

In this chapter, we will detail the specific Lean tools implemented, including the revamped Relatórios Diários de Campo (RDCs) and automated Histograms, and discuss how they addressed the inefficiencies identified earlier. We will also present the results achieved through these implementations, such as improvements in data accuracy, reduction in processing times, and enhanced communication across departments.

The chapter concludes with an analysis of the overall impact of the Lean methodologies on SNEF Brasil's project management practices, highlighting lessons learned and recommendations for sustaining continuous improvement. Through this exploration, we aim to demonstrate how a methodical and inclusive approach to Lean implementation can drive meaningful change and set the foundation for ongoing organizational excellence.

5.2 RDC Standardization

5.2.1 The urge of digitalisation

One of the pivotal steps in implementing Lean methodologies at SNEF Brasil was the digitalization and standardization of the Relatórios Diários de Campo (RDCs). Recognizing the multitude of inefficiencies inherent in the traditional paper-based RDCs—such as delays, errors, and fragmented data—the urgent need to transition to a digital platform became evident. This shift was instrumental in not only streamlining the data collection process but also in laying the groundwork for further automation and integration within the company's project management systems.

Transition to Excel Spreadsheets

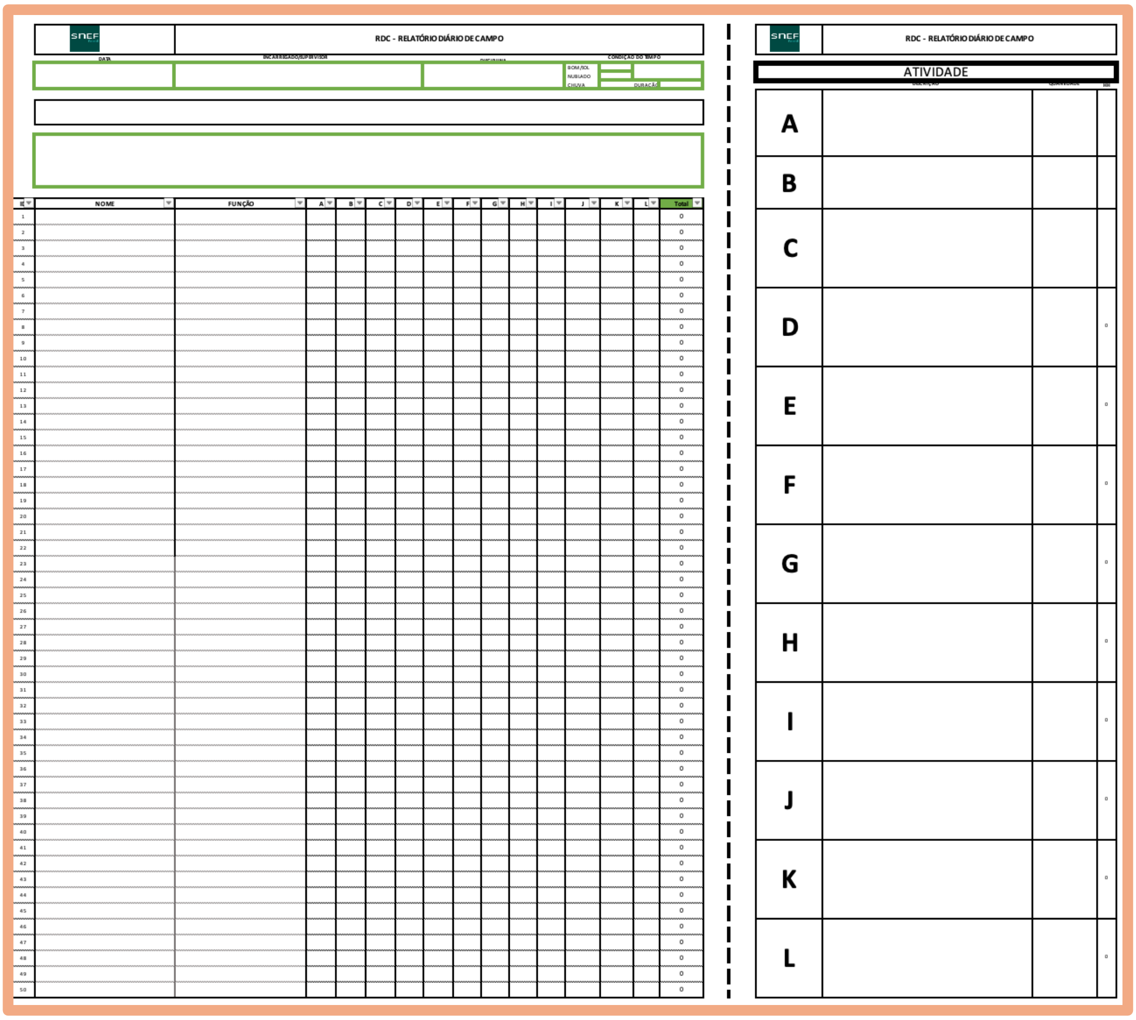


Figure 6: RDC Example (Excel Sheet)

The initial improvement involved replacing the manual, paper-based RDCs with standardized Excel spreadsheets. This move towards digitalization offered several immediate advantages:

- **Elimination of Manual Paper Reports:** By moving to Excel, the reliance on physical paper forms was completely eradicated. This reduced the risks associated with lost or damaged documents and eliminated the time-consuming process of physically transporting reports from the construction site to the headquarters.
- **Improved Data Accuracy and Legibility:** Digital entry eliminated issues related to illegible handwriting and transcription errors, ensuring that the data collected was accurate and reliable.
- **Streamlined Data Transmission:** Excel files could be easily shared via email or cloud services, significantly reducing the time taken to transmit data.
- **Standardization of Reporting Formats:** Implementing a standardized Excel template ensured consistency in how data was recorded across different projects

and teams. This standardization facilitated easier aggregation and comparison of data, enhancing overall analysis.

While the transition from manual, paper-based Relatórios Diários de Campo (RDCs) to standardized Excel spreadsheets marked a significant step forward in digitalizing the data collection process, certain challenges persisted. These limitations hindered the full realization of Lean principles and highlighted the need for further improvements. The primary difficulties that remained after the initial digitalization were:

1. **Inconsistent Worker and Activity Naming Conventions**
    - **Variability in Worker Names:** Construction managers had the liberty to enter workers' names as they saw fit. This freedom led to inconsistencies such as variations in spelling, use of nicknames, or omission of full names. As a result, it became difficult to accurately trace and track individual workers across different reports and projects.
    - **Inconsistent Activity Descriptions:** Similar to worker names, activity names were not standardized. Construction managers described activities using their own terminology, which could vary widely even for the same tasks. This inconsistency made it challenging to correlate reported activities with those specified in the contract or project plan.
2. **Difficulty in Tracing Worker Roles and Functions**
    - **Lack of Role Specification:** The initial Excel spreadsheets did not require or enforce the inclusion of workers' roles or functions. Without this information, analyzing labor distribution and understanding the allocation of specific skill sets became problematic.
    - **Impaired Resource Management:** The inability to accurately identify who was performing which tasks hindered effective resource management. It was difficult to assess whether workers were being utilized efficiently or if there were gaps in skill deployment.
3. **Challenges in Contract Compliance Verification**
    - **Alignment with Contractual Activities:** Due to the non-standardized activity names, verifying whether the on-site activities aligned with contractual obligations was arduous. This misalignment posed risks of deviating from the agreed scope of work, potentially leading to disputes or financial discrepancies.
    - **Inadequate Audit Trail:** The inconsistencies in data entry limited the ability to perform audits or reviews to ensure compliance with contractual terms and project specifications.
4. **Limited Data Usability for Advanced Analysis**

- **Data Fragmentation:** Inconsistent naming conventions resulted in fragmented data that was difficult to aggregate or analyze collectively. This fragmentation impeded the ability to generate meaningful insights or identify trends across projects.
- **Reduced Automation Potential:** The variability in data entries prevented the effective use of automation tools and functions within Excel. Functions such as sorting, filtering, and generating automated reports were less effective or required additional manual intervention.

Despite the significant advancements achieved through the initial digitalization of the RDCs, the persistent challenges highlighted the need for further enhancement to fully realize the benefits of Lean methodologies. The issues with inconsistent worker and activity naming conventions, difficulty in tracing roles and functions, challenges in contract compliance verification, and limited data usability underscored that the digital transition was only the first step. Recognizing that continuous improvement is a core principle of Lean thinking, we understood that additional measures were necessary to optimize the RDC process.

5.2.2 RDC Continuous Improvement

In this phase, we focused on refining the RDCs by introducing standardized naming conventions, implementing data validation mechanisms, and enhancing integration with project management systems. These efforts aimed to address the remaining inefficiencies, improve data accuracy, and facilitate more effective resource management, ultimately driving the organization closer to its Lean objectives.

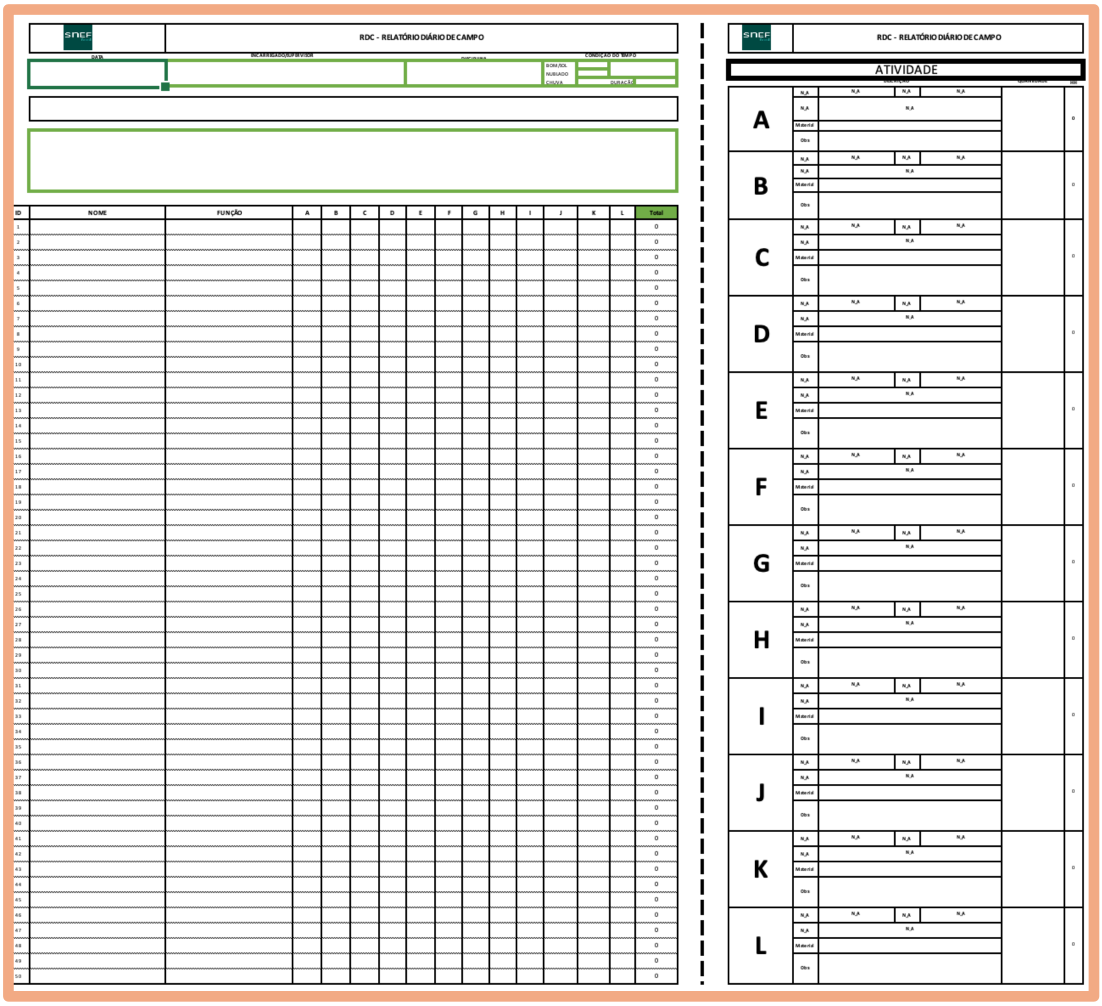


Figure 7: RDC Example (Automation phase)

For this improvement, I focused on three general steps to eliminate common waste across all projects:

1. Automation of Hours Tracking

I implemented an automated system for tracking working hours, which provided precise information on the total hours worked per activity and per worker. This advancement significantly improved data traceability by allowing us to:

- **Monitor Individual Contributions:** Accurately know how many hours each worker contributed, benefiting Human Resources in payroll and performance assessments.
- **Compare Actual vs. Planned Work:** Evaluate the real work done against the planned schedule, enabling us to verify if the project was on track and make timely adjustments.

2. Standardization of Worker Names

To address inconsistencies in worker identification, I standardized the naming convention for all personnel:

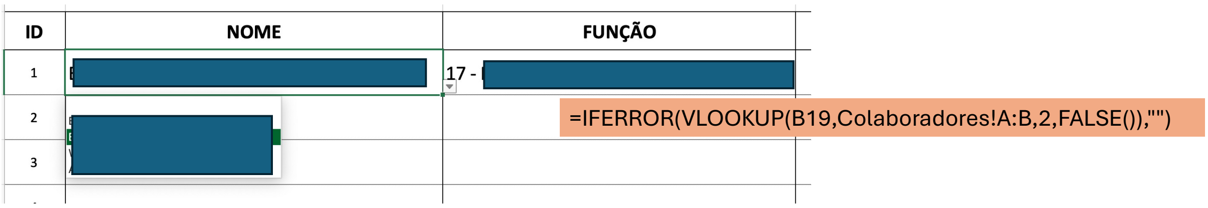


Figure 8: RDC Example – Standardization of Worker Names

- **Creation of an Authorized Worker List:** Using data from contracts and HR records, we compiled a list of workers eligible to work on the project, along with their designated functions.
- **Simplified Selection Process:** The construction manager could now select a worker's name from a predefined list, which automatically populated their role or function.

This standardization eliminated confusion caused by nicknames or misspellings and reduced time wasted in verifying worker details with HR.

3. Standardization of Activity Descriptions

I aligned activity selection with the established hierarchy in the Chronogram:

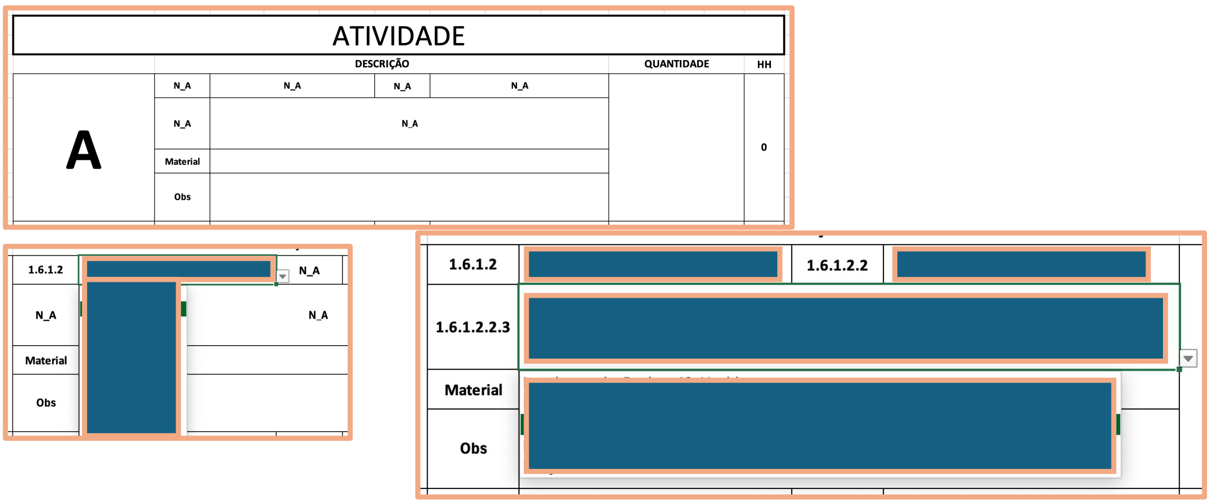


Figure 9: RDC Example – Standardization of Activity Description

- **Consistent Activity Hierarchy:** Activities were standardized according to the project's schedule and contractual terms.
- **Improved Data Allocation:** This consistency helped accurately assign hours to specific activities within our data processing system.

By doing so, we enhanced our ability to trace completed activities and ensured that all reported work corresponded with the planned tasks.

LEAN Analysis

These improvements directly addressed several forms of waste identified in Lean methodology:

- **Defects (Errors in Data Entry):** Standardizing worker names and activities reduced errors caused by inconsistent or incorrect data entries.
- **Overprocessing:** Automating hours calculation eliminated redundant manual computations, streamlining the reporting process.
- **Waiting Time:** Immediate access to accurate data reduced delays in decision-making and improved responsiveness to on-site developments.
- **Motion Waste:** Eliminating the need to cross-reference worker functions with HR minimized unnecessary movement and communication.

By automating hours tracking and standardizing both worker names and activity descriptions, we eliminated significant inefficiencies in the data management process. These steps not only improved accuracy and traceability but also aligned with Lean principles by reducing waste and enhancing overall productivity. The result was a more efficient workflow that better supported project management objectives and facilitated continuous improvement.

5.3 Histogram Standardization

Building upon the enhancements made to the Relatórios Diários de Campo (RDCs), the next critical focus in our Lean implementation was the standardization of the Histograms. Histograms are essential tools for visualizing workforce distribution over time and play a pivotal role in effective resource management and planning. However, as identified in our pre-Lean analysis, the existing Histograms were hindered by manual data entry errors, inconsistencies, and a lack of integration with other project management systems.

While the initial digitalization of the RDCs provided a more reliable and standardized dataset, the full potential of this improvement could not be realized without addressing the accompanying Histograms. Recognizing this, we aimed to transform the Histograms from static, manually updated charts into dynamic, automated tools capable of delivering real-time insights and supporting data-driven decision-making.

5.3.1 Histogram Functionality

The Histogram serves as a critical tool designed to present the daily workload for each project. To fulfill this primary objective, each column in the Histogram represents a specific contract day. It is essential to differentiate between weekdays, weekends, and holidays because the allowable working hours vary—workers are expected to work nine hours on weekdays but only eight hours on Fridays, Saturdays, Sundays, and holidays. To visually represent this difference, we incorporate a color-coding system: green for weekdays and yellow for weekends and holidays.

Furthermore, we need to differentiate each front within the project. A front refers to a team led by a construction manager focused on a main activity or goal. Consequently, there could be several teams involved on the same day, each engaged in different activities. For large projects where various activities occur simultaneously, it's necessary to distinguish:

- **Hours per Activity:** Tracking the time spent on each specific task.
- **Hours per Location Worked:** Differentiating work based on the physical areas or sites.
- **Day Work versus Night Work:** Separating shifts to account for different working conditions and labor regulations.

These distinctions are crucial and may vary depending on contractual agreements and project requirements.

Challenges Prior to Lean Implementation

- Before implementing Lean methodologies, obtaining all this detailed information was cumbersome. All relevant data had to be extracted manually from the Relatórios Diários de Campo (RDCs), making it difficult to trace specific details without sifting through hundreds or even thousands of individual reports. This manual process was time-consuming and inefficient. I personally experienced these challenges at the start of my internship, which fueled my determination to improve the Histogram's functionality. By streamlining the Histogram, we aimed to facilitate easier access to vital information, enhance data traceability, and support more effective project management.

5.3.2 Differentiating the Fronts

Our primary objective was to differentiate the fronts to enable the separation of data for each activity in large projects. To achieve this, I devised a system of grouping lines (separated by a blue color) where each block represents a front, labeled with the name of the construction manager. Each line within the block corresponds to the functions of each team member. This configuration allows us to easily distinguish the hours worked per front per day.

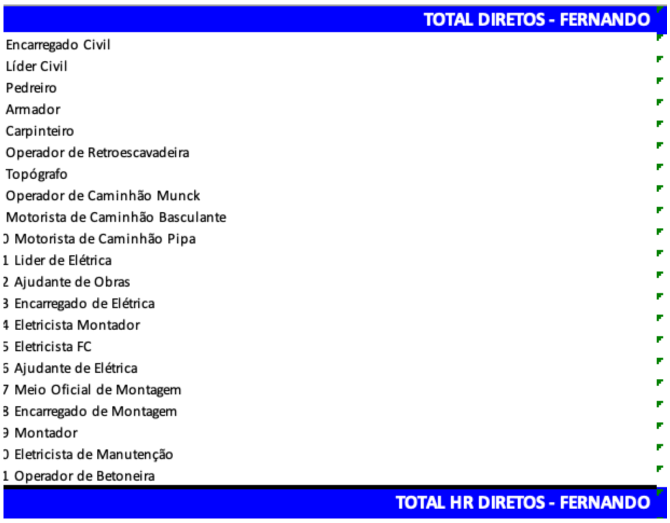


Figure 10: Histogram – Front Definition

By structuring the Histogram in this way, we could:

- **Visualize Workforce Allocation:** Clearly see how many workers were assigned to each front on any given day.
- **Track Activity Progress:** Monitor the distribution of labor across different activities and fronts.
- **Improve Resource Planning:** Make informed decisions about resource allocation based on accurate, front-specific data.

5.3.3 Linking RDCs to the Histogram

A significant improvement was establishing a link between the RDCs and the Histogram. Since each front was populated with functions, and each worker in the RDC is automatically associated with a function, we leveraged this relationship to automate data transfer. The process involved:

- **Copying RDC Data:** Importing the RDC spreadsheet into the Histogram.
- **Labeling with Construction Manager and Date:** Assigning a unique identifier combining the construction manager's name and the date (e.g., **FERNANDO-29.07.2024**).
- **Automating Worker Counts:** Implementing functions that, based on the identifier, populate the corresponding column in the Histogram with the number of workers per function working under that manager on that day.

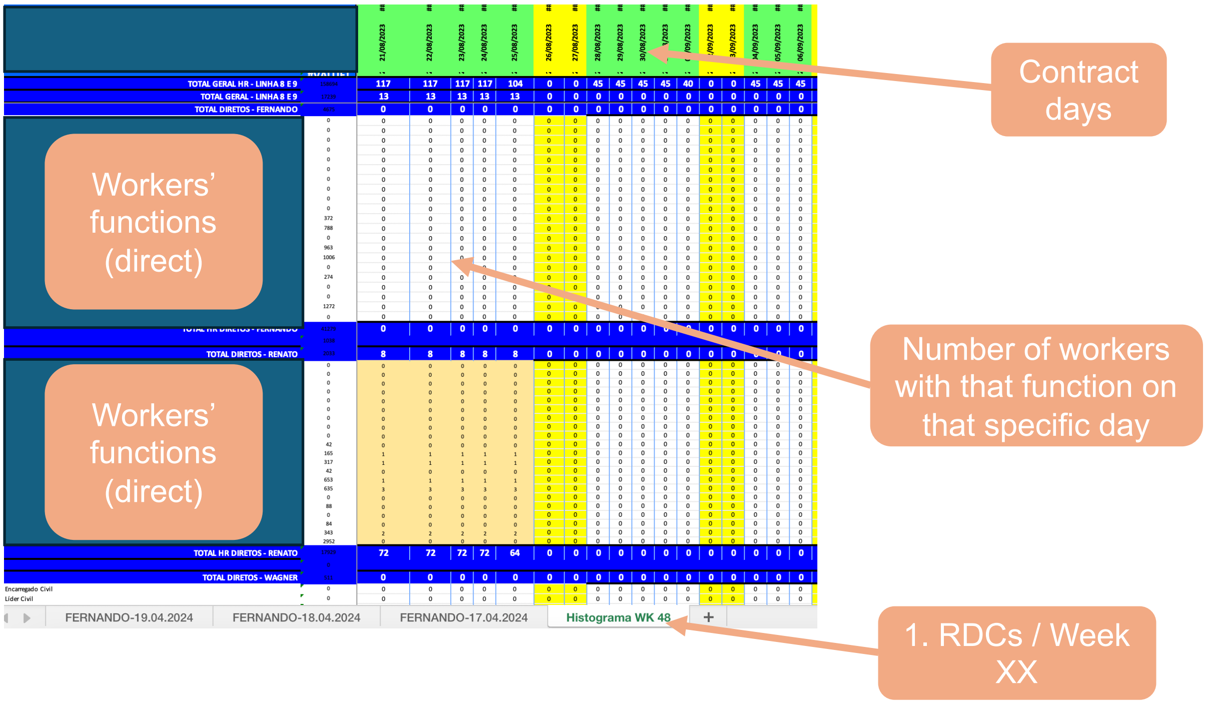


Figure 11: Histogram Standardization (with indications)

This automation allowed us to:

- **Eliminate Manual Data Entry:** Reduce errors and save time by automating the population of the Histogram.
- **Ensure Data Consistency:** Maintain uniformity in data across the RDCs and Histograms.
- **Facilitate Real-Time Updates:** Provide up-to-date information for decision-making without delay.

5.3.4 Color and Display Automation

With the worker counts automated, the next step was to automate the display of the Histogram for better visualization. I developed a VBA (Visual Basic for Applications) code that:

- **Applied Color Coding:** Automatically colored cells **green** for weekdays and **yellow** for weekends and holidays, based on the date.
- **Separated Fronts Visually:** Used **blue shading** to delineate different fronts within the Histogram.

- **Verified Imposable Working Hours:** Included a function to check whether the day's allowable working hours were eight or nine, depending on the day, and adjusted calculations accordingly.

```
Private Sub Worksheet_SelectionChange(ByVal Target As Range)

Dim DateCell As Range
Dim dayOfWeek As Integer
Dim sHoliday As Boolean

Set DateCell = Worksheets("Histograma WK 48").Range("C4:XX4")

For Each cell In DateCell

    dayOfWeek = 0
    sHoliday = False

    dayOfWeek = Weekday(cell.Value, vbMonday)
    sHoliday = isHoliday(cell.Value, Worksheets("Histograma WK 48").Range("B177:B205"))

    If dayOfWeek >= 6 Or sHoliday Then
        cell.Interior.color = vbYellow
    End If
Next


Dim DCell As Range
Dim i As Integer
Dim excludedRows() As Variant

'Définir les lignes à exclure
excludedRows = Array(5, 6, 7, 29, 30, 31, 53, 54, 55, 77, 78, 100, 101, 123)

Set DCell = Worksheets("Histograma WK 48").Range("A1:A123")

i = 0
For Each cell In DCell
    i = i + 1
    If AppartientListe(i, excludedRows()) Then
    'If i = 15 Then
        cell.EntireRow.Interior.color = vbBlue
    End If
Next


End Sub
```

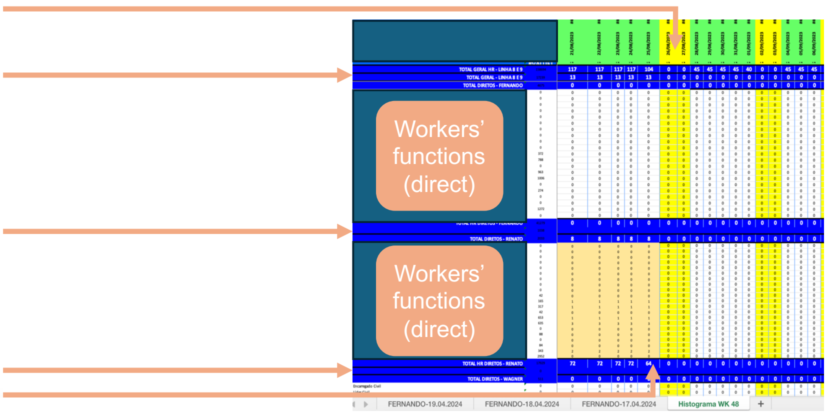


Figure 12: Histogram Standardization – VBA Display Code

These enhancements improved the Histogram by:

- **Enhancing Readability:** Making it easier for users to interpret the data at a glance.
- **Ensuring Compliance:** Verifying that work hours adhered to labor regulations and contractual agreements.
- **Reducing Manual Effort:** Automating repetitive formatting tasks to save time and reduce errors.

5.3.5 Advanced Color Coding and Data Analysis

For large projects, it was essential to differentiate various aspects such as locations where activities were performed and, most importantly, to control the hours worked. To address this, I created several VBA functions that enabled:

- **Counting Hours by Color Code:** Summing hours based on the color-coded cells, taking into account the distinction between eight and nine-hour workdays.
- **Automated Data Summaries:** Generating automatic calculations of total hours worked per activity, location, or shift (day/night), without the need to manually sift through the entire Histogram.

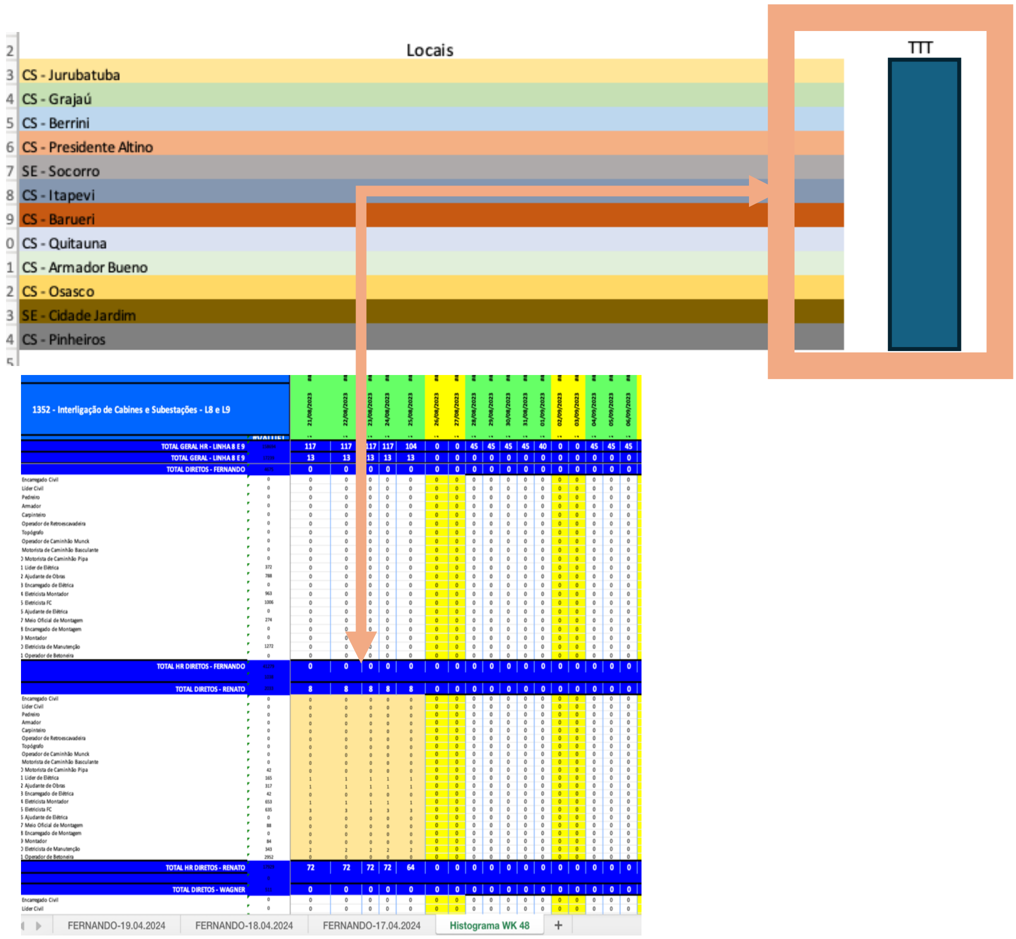


Figure 13: Histogram Standardization – Colour Automation

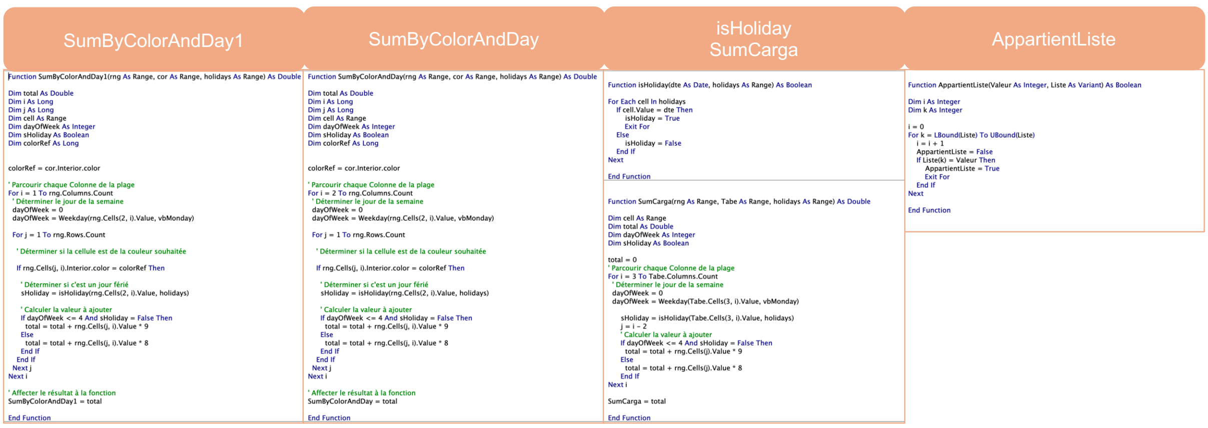


Figure 14: Histogram Standardization - Color Automation Code (VBA)

This advancement significantly streamlined the data processing for activity analysis:

- **Immediate Access to Information:** Provided quick summaries and insights without manual intervention.
- **Improved Accuracy:** Reduced the potential for human error in calculations.
- **Enhanced Decision-Making:** Equipped managers with timely and precise data to make informed decisions.

5.3.6 Lean Analysis

The standardization and automation of the Histograms directly addressed several forms of waste identified in Lean methodology, resulting in significant improvements in efficiency, accuracy, and resource management.

- **Elimination of Manual Data Entry Errors:** By automating the link between the RDCs and the Histogram, we eliminated manual data entry, thereby reducing errors associated with transcribing data from one system to another. Automated data transfer ensures that the information is accurate and consistent across all tools.
- **Reduction of Overprocessing:** Previously, significant time was spent manually compiling and updating Histograms, which was unnecessary work that did not add value. Automation through VBA scripting reduced this overprocessing by streamlining the data compilation process.
- **Minimization of Waiting Times:** Automation of data updates provided real-time access to workforce distribution and workload information. This immediacy reduced waiting times for managers who previously had to wait for manually updated reports to make informed decisions.
- **Enhanced Standardization and Consistency:** Standardizing the Histograms ensured that all projects used a uniform format and methodology for tracking workforce data. This consistency facilitated better communication and understanding among team members and across departments.
- **Improved Resource Utilization:** Automating routine tasks freed up personnel to focus on more value-added activities, such as analyzing data insights and improving project strategies, rather than spending time on manual data entry and report generation.
- **Better Visualization and Data Accessibility:** Automating color coding and display features improved the visualization of critical data, making it easier for stakeholders to quickly interpret information and identify areas needing attention.
- **Integration with Project Management Systems:** By linking the RDCs and Histograms, we integrated previously isolated systems, enhancing overall data flow and collaboration between teams.
- **Continuous Improvement and Adaptability**: The use of VBA scripting and Excel functions allowed for easy adjustments and scalability, enabling the tools to adapt to different project sizes and requirements, which is in line with the Lean principle of continuous improvement.

Through the lens of Lean methodology, the standardization and automation of the Histograms significantly reduced waste and enhanced efficiency within the project management process at SNEF Brasil. By addressing key areas of waste—such as defects, overprocessing, waiting, and underutilized talent—we optimized our data management and reporting systems. These improvements not only streamlined current operations but also established a foundation for ongoing optimization and adaptability, fostering a culture of continuous improvement within the organization.

By systematically applying Lean principles to the Histogram standardization, we achieved a more efficient, accurate, and user-friendly tool that significantly improved workforce management and planning. The enhanced Histograms provided real-time insights, facilitated better decision-making, and aligned with our overall goal of eliminating waste and increasing productivity throughout the project lifecycle.

5.4 Results

As previously explained, the primary metric for evaluating the effectiveness of the Lean implementation (KPI) was the time required for each activity in the Value Stream Map (VSM). To assess the impact of the new tools, I conducted a comparative analysis on the same three projects of varying sizes—small, medium, and large—after one month of implementing the Lean methodologies. The results were significant and demonstrated substantial improvements in process efficiency.

Summary of Time Reduction Across Activities

The table below presents the time (in business days) required for each activity before (February 2024) and after (April 2024) the Lean implementation:

Activity	**Responsible**	**Feb-24**	**Apr-24**
Start		0.00	0.00
Development of Schedule	Planner / PM	5.00	5.00
Validation of Activities	Field Supervisor	5.00	5.00
Pre-filling of RDCs / RDOs	Planner	0.50	1.00
Validation of Standards	PM	0.50	0.50
Start of Construction			
Filling out RDCs	Field Supervisor	0.10	0.10
Sending RDCs	Field Supervisor	7.00	7.00
Data Processing and Analysis Activities:			
Validation of RDCs	*Engineering Assistant*	*0.20*	*0.20*
Filling out RDOs	*Planner*	*0.50*	*0.20*
Validation of RDOs / Sending to Client	*PM*	*0.30*	*0.00*
Updating Histogram	*Planner*	*0.80*	*0.10*
Updating Schedule	*Planner*	*0.80*	*0.10*
Updating Lean Metrics	*Planner*	*0.80*	*0.25*

Consolidation of KPIs	*Planner*	*0.80*	*0.25*
Productivity Assessment	Planner / PM	0.50	0.50
Internal Presentation of Project Progress	Planner / PM	0.00	0.00
Total Time		**22.80**	**20.20**

Table 3: Results

Analysis of Data Processing and Analysis Activities

Given that the focus of this study is on the data processing and analysis aspects of the project management process, we extracted the activities directly related to data treatment for a more detailed comparison:

Data Activity	**Responsible**	**Feb-24**	**Apr-24**
Validation of RDCs	Engineering Assistant	0.20	0.20
Filling out RDOs	Planner	0.50	0.20
Validation of RDOs / Sending to Client	PM	0.30	0.00
Updating Histogram	Planner	0.80	0.10
Updating Schedule	Planner	0.80	0.10
Updating Lean Metrics	Planner	0.80	0.25
Consolidation of KPIs	Planner	0.80	0.25
Total Time for Data Activities		4.20	1.10

Table 4: Results pt. 2

Interpretation of Results

- **Total Project Time Reduction:** The overall time from the start of the project decreased from 22.8 business days to 20.2 business days after implementing Lean methodologies, reflecting a reduction of 2.6 business days.
- **Data Processing Time Reduction:** Focusing on the data processing and analysis activities, the time decreased from 4.2 business days to 1.1 business days, representing a significant reduction of approximately 74%.

Conclusion

The implementation of Lean tools and the standardization of processes led to substantial time savings, particularly in the data processing and analysis stages. The reduction from 4.2 to 1.1 business days in these activities means that tasks which previously took nearly a week to complete can now be accomplished in less than two days.

This improvement has several important implications:

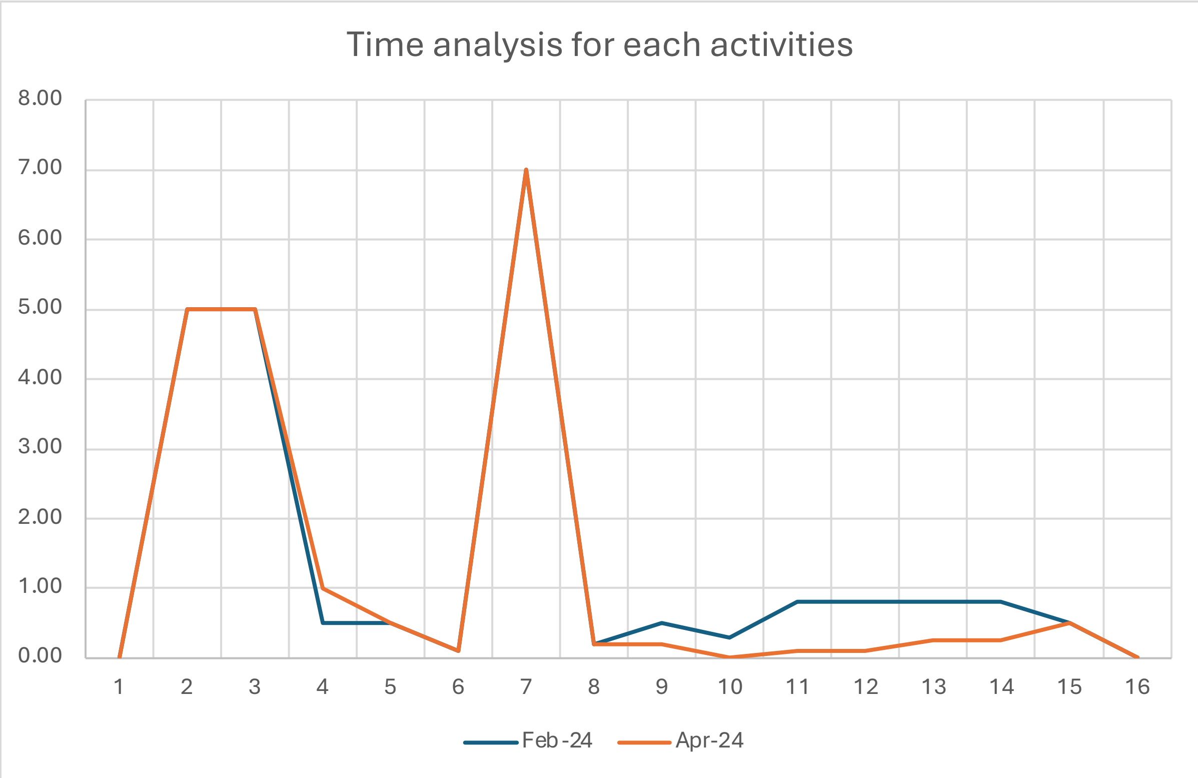
- **Increased Efficiency:** The team can process and analyze data more quickly, reducing delays and accelerating project timelines.

- **Enhanced Proactivity:** With faster data processing, the team has shifted from being reactive to proactive. They can now anticipate issues, identify trends early, and make informed decisions promptly.
- **Improved Data Quality and Reliability:** The standardized processes and automated tools have reduced the risk of errors, resulting in more accurate and reliable data.
- **Empowered Decision-Making:** Project Managers (PMs) are now equipped with stronger, data-driven insights during meetings and decision-making processes, enhancing overall project management effectiveness.
- **Resource Optimization:** The time saved allows team members to dedicate more effort to specialized analyses and strategic tasks, further contributing to project success.

The significant reduction in time required for data processing and analysis demonstrates the effectiveness of the Lean methodologies applied. By eliminating waste, standardizing processes, and leveraging automation, we have not only streamlined operations but also enhanced the team's ability to contribute valuable insights to the project. This transformation underscores the importance of continuous improvement and the tangible benefits that Lean principles can bring to project management practices.

5.5 The Next Steps

To further our commitment to continuous improvement and deepen the application of Lean methodologies at SNEF Brasil, we turned our attention to remaining inefficiencies identified in the Value Stream Map (VSM). By representing the VSM in a graphical format—with business days on the Y-axis and activities on the X-axis—we were able to visually highlight the areas consuming the most time. This analysis revealed that Activity 7: Sending RDCs was a significant bottleneck, representing a major source of waste in our process.



Graph 1: Activity per Business days (before and after)

Recognizing the critical need to address this bottleneck, we embraced the 5S methodology of continuous improvement, focusing on the principles of Sort, Set in Order, Shine, Standardize, and Sustain. Our goal was to eliminate waste, streamline workflows, and enhance overall efficiency.

Identifying the Bottleneck

The graphical representation of the VSM made it evident that Sending RDCs was disproportionately time-consuming, with a delay of 7 business days between the completion of work on-site and the reception of the Relatórios Diários de Campo (RDCs) at headquarters. This delay impeded timely decision-making, affected data accuracy, and hindered our ability to respond swiftly to on-site developments.

Collaborative Problem-Solving through Design Thinking

To address this challenge, we employed a design thinking approach, organizing collaborative workshops that included a diverse group of stakeholders—from company executives and project managers to data analysts, field supervisors, and on-site workers. These sessions aimed to foster creative problem-solving and generate innovative solutions.

During the workshops, we:

- **Presented the Current State:** Shared the findings of our analysis, emphasizing the impact of the bottleneck on project timelines and efficiency.

- **Encouraged Open Dialogue:** Invited participants to share their insights, experiences, and ideas for overcoming the identified challenges.
- **Facilitated Brainstorming Sessions:** Conducted activities to stimulate creative thinking and explore a wide range of potential solutions.

Proposed Solution: Developing a Mobile Application for RDCs

Through this collaborative process, a consensus emerged around a transformative solution:

"Develop a software application that allows the construction manager to complete and submit the RDCs directly from their mobile device, thereby eliminating the 7-day delay between the workday and the reception of the RDC."

This solution aligns with our Lean objectives by:

- **Eliminating Waste (Sort):** Removing unnecessary steps in the data submission process.
- **Organizing Workflow (Set in Order):** Streamlining data collection and transmission for efficiency.
- **Ensuring Data Accuracy (Shine):** Enhancing the clarity and quality of data through digital entry.
- **Standardizing Processes (Standardize):** Implementing a consistent method for all teams to follow.
- **Maintaining Improvements (Sustain):** Establishing practices that encourage ongoing adherence to the new system.

Designing the New Workflow:

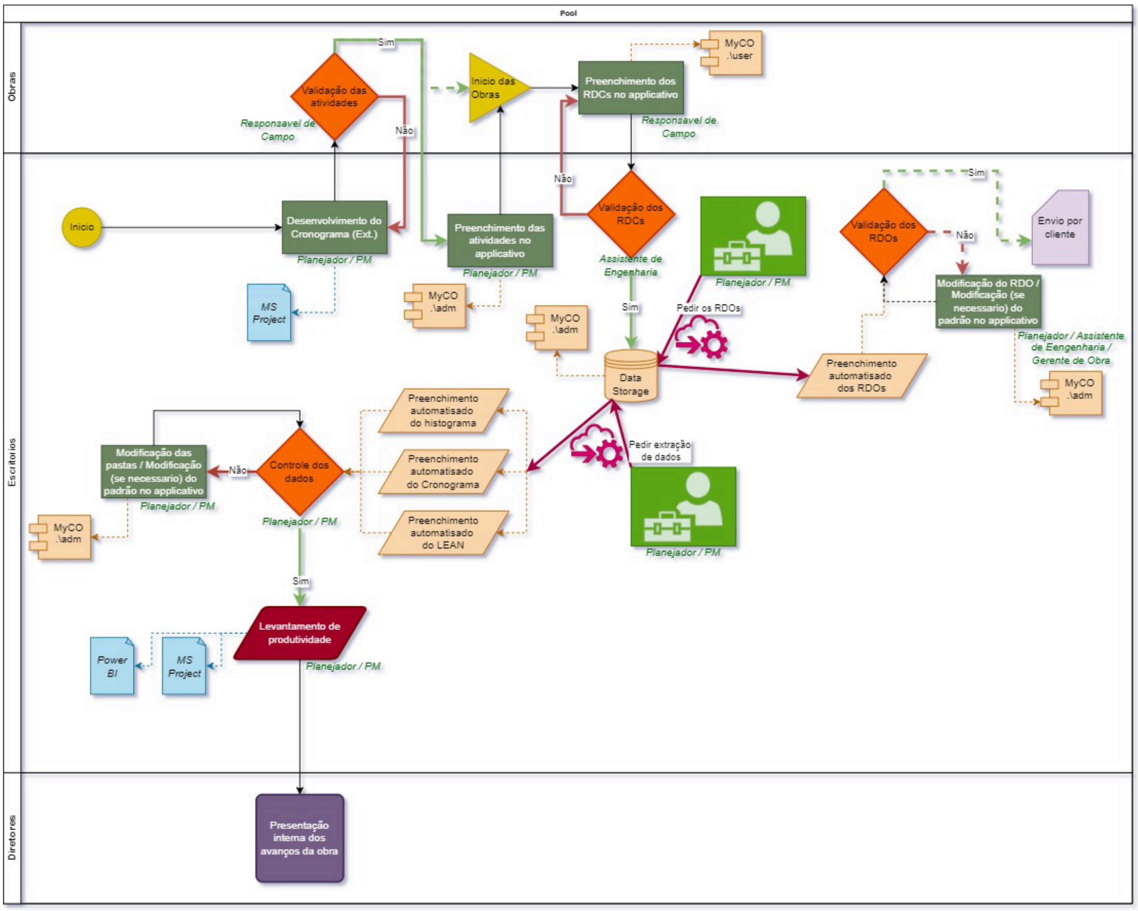


Figure 15: VSM – Proposition New Workflow

Estimated Impact on Project Timelines

We projected the potential improvements by updating our activity timeline. The table below compares the time (in business days) required for each activity before Lean implementation (February 2024), after initial Lean improvements (April 2024), and the estimated times following the adoption of the mobile application.

Activity	Responsible	Feb-24	Apr-24	Estimation
Start		0.00	0.00	0.00
Development of Schedule	Planner / PM	5.00	5.00	5.00
Validation of Activities	Field Supervisor	5.00	5.00	5.00
Pre-filling of RDCs / RDOs	Planner	0.50	1.00	1.00
Validation of Standards	PM	0.50	0.50	0.50
Start of Construction				
Filling out RDCs	Field Supervisor	0.10	0.10	1.00
Sending RDCs	Field Supervisor	7.00	7.00	0.00

Data Processing and Analysis Activities:				
Validation of RDCs	Engineering Assistant	0.20	0.20	0.20
Filling out RDOs	Planner	0.50	0.20	0.00
Validation of RDOs / Sending to Client	PM	0.30	0.00	0.00
Updating Histogram	Planner	0.80	0.10	0.00
Updating Schedule	Planner	0.80	0.10	0.00
Updating Lean Metrics	Planner	0.80	0.25	0.00
Consolidation of KPIs	Planner	0.80	0.25	0.10
Productivity Assessment	Planner / PM	0.50	0.50	0.50
Internal Presentation of Project Progress	Planner / PM	0.00	0.00	0.10
Total Time		**22.80**	**20.20**	**13.40**

Table 5: Prevision Results after Implementation

Analysis of Projected Improvements

- **Elimination of the 7-Day Delay:** The most significant reduction is observed in Sending RDCs, decreasing from 7.00 to 0.00 business days. This change eliminates the major bottleneck identified.
- **Automation of Data Processing:** Activities such as Filling out RDOs, Updating Histogram, Updating Schedule, and Updating Lean Metrics are reduced to 0.00 business days due to automation and real-time data integration.
- **Overall Time Reduction:** The total project time decreases from 22.80 business days in February to 13.40 business days in the estimated scenario—a 41% reduction from the initial timeframe.

Applying the 5S Methodology

The proposed solution embodies the 5S principles as follows:

- **Sort (Seiri):** Removed unnecessary steps by eliminating manual data transmission and redundant data entry.
- **Set in Order (Seiton):** Organized the workflow so that RDCs are completed and submitted in a streamlined, efficient manner.
- **Shine (Seiso):** Improved data quality by reducing errors through digital entry and immediate validation.
- **Standardize (Seiketsu):** Established a uniform process for RDC submission across all projects and teams.

- **Sustain (Shitsuke):** Developed training programs and support systems to maintain adherence to the new process and encourage ongoing improvement.

Benefits of the Mobile Application

- **Real-Time Data Availability:** Immediate access to up-to-date information enhances decision-making and responsiveness.
- **Improved Data Accuracy:** Digital forms reduce errors associated with manual entry and illegible handwriting.
- **Enhanced Communication:** Streamlines communication between on-site teams and headquarters.
- **Resource Optimization:** Frees up time for planners and project managers to focus on strategic tasks rather than administrative duties.

Future Considerations

Implementing the mobile application is a significant step towards operational excellence, but continuous improvement requires ongoing evaluation. Future actions include:

- **Monitoring and Evaluation:** Regularly assess the effectiveness of the new system and make adjustments as needed.
- **Scalability:** Explore opportunities to extend the application's functionality to other areas, such as inventory management or quality control.
- **Feedback Mechanisms:** Establish channels for users to provide feedback, ensuring the system evolves to meet their needs.
- **Training and Support:** Provide comprehensive training to ensure all users are proficient with the new technology.

By identifying and addressing the primary bottleneck in our process through collaborative problem-solving and the application of the 5S methodology, we have charted a path toward significant efficiency gains. The development of a mobile application for RDC submission is projected to reduce project timelines dramatically, enhance data accuracy, and improve overall operational efficiency. This initiative exemplifies our dedication to Lean principles and our commitment to fostering a culture of continuous improvement at SNEF Brasil.

5.6 Conclusion

In this chapter, we detailed the implementation of Lean methodologies at SNEF Brasil and analyzed the significant improvements achieved in project management processes. By focusing on the standardization and automation of the Relatórios Diários de Campo (RDCs) and Histograms, we addressed critical inefficiencies related to manual data entry, inconsistent reporting, and fragmented workflows.

The initial digitalization of the RDCs marked a pivotal step toward enhancing data accuracy and streamlining communication between on-site teams and headquarters. This transition eliminated issues associated with illegible handwriting and transcription errors, reduced delays in data transmission, and established a standardized reporting format across all projects. However, challenges such as inconsistent naming conventions for workers and activities persisted, highlighting the need for continuous improvement.

To further optimize the process, we introduced automation and standardization measures, including:

- **Automation of Hours Tracking**: Implementing systems to automatically calculate total hours worked per activity and per worker, improving data traceability and enabling comparisons between actual and planned work.
- **Standardization of Worker Names and Activities**: Creating predefined lists based on contractual agreements and HR records to ensure consistent identification of workers and activities, facilitating accurate tracking and analysis.
- **Integration with Histograms**: Establishing links between the RDCs and Histograms allowed for real-time updates and enhanced visualization of workforce distribution, aiding in effective resource management.

These improvements led to a substantial reduction in the time required for data processing and analysis activities—from 4.2 business days to 1.1 business days—representing a 74% improvement. This efficiency gain transformed the team's role from reactive data processors to proactive analysts, empowering them to anticipate issues and support Project Managers with timely, data-driven insights.

Recognizing the importance of continuous improvement, we identified the Sending of RDCs as a remaining bottleneck. Applying the 5S methodology and engaging in collaborative design thinking sessions with stakeholders, we proposed the development of a mobile application to enable construction managers to submit RDCs directly from their devices. This solution aimed to eliminate the seven-day delay, further streamline data processing, and enhance real-time decision-making capabilities.

However, due to resource constraints, SNEF Brasil was unable to pursue the development of the proposed software internally. In response, efforts were directed toward developing a business model and product charter, engaging with commercial teams under managerial supervision to explore potential avenues for implementation. During this period, organizational changes occurred, and I assumed greater responsibility for the data analysis processes within the company following my manager's departure. The increased workload and shifting priorities meant that the software development initiative could not be advanced further at that time.

Simultaneously, taking on responsibility for various projects provided deeper insights into the specific information needs and challenges faced in project management. This experience enabled me to refine and adapt the tools already developed, tailoring them to the unique requirements of each project. While confidentiality obligations prevent a detailed discussion of these adaptations, the continued focus on enhancing existing tools contributed to ongoing improvements in efficiency and data accuracy.

The Lean implementation at SNEF Brasil demonstrated the profound impact that process standardization, automation, and continuous improvement can have on organizational efficiency. By systematically identifying and addressing inefficiencies, we achieved significant reductions in processing times, enhanced data reliability, and improved resource utilization. Although some initiatives, such as the development of a mobile application, could not be realized due to resource limitations, the commitment to Lean principles fostered a culture of adaptability and proactive problem-solving.

The journey highlighted the importance of flexibility in the face of changing circumstances and the value of leveraging existing tools to meet evolving project demands. As SNEF Brasil continues to navigate the complexities of project management in the engineering and construction industry, the lessons learned from this Lean transformation provide a strong foundation for future advancements and sustained operational excellence.

6 CONCLUSION

6.1 Summary of Findings

This thesis aimed to explore how Lean production methodologies, specifically Value Stream Mapping (VSM) and the 5S methodology, can be applied to improve data management and project productivity in construction projects at SNEF Brasil. Through the detailed case study, a series of key findings emerged.

Firstly, the implementation of Lean tools led to notable improvements in the efficiency and accuracy of SNEF Brasil's project management processes. The adoption of VSM enabled the identification and subsequent elimination of bottlenecks in data handling, particularly in the transmission of daily field reports (RDCs). By mapping the flow of data from collection to analysis, inefficiencies such as delays and errors were revealed and addressed, reducing waste and improving overall project communication.

Secondly, the 5S methodology contributed significantly to the organization and standardization of data workflows. This ensured that data was collected, processed, and transmitted in a timely and structured manner. The application of 5S principles not only improved workplace organization but also facilitated faster decision-making and reduced lead times. By establishing clear protocols for data handling and minimizing unnecessary movements of information, SNEF Brasil was able to enhance the productivity of its teams and streamline project execution.

Moreover, the integration of Lean tools into data management proved to be a valuable strategy for improving both operational efficiency and the quality of project outcomes. This demonstrates the adaptability of Lean methodologies, traditionally associated with manufacturing, to other sectors such as construction and data-intensive environments. The ability of Lean to evolve and remain relevant in modern industries, including those shaped by digitalization and big data, was a key insight from this research.

6.2 Challenges and Limitations

Despite the positive results, several challenges were encountered during the implementation of Lean tools. One of the primary obstacles was resistance to change, particularly among staff accustomed to traditional project management practices. While training sessions helped to mitigate this resistance, a cultural shift toward continuous improvement and Lean thinking will take time to fully embed across the organization.

Additionally, the research faced limitations related to data availability and time constraints. The reliance on manual data collection prior to Lean implementation meant that historical data was incomplete or inconsistent, which affected the baseline measurements. Furthermore, the relatively short timeframe for the study limited the ability to observe the long-term effects of Lean interventions on project productivity. Future research should aim for a longer evaluation period to capture the sustained impact of Lean methodologies.

6.3 Recommendations for Future Implementation

The findings from this research suggest several recommendations for the continued implementation of Lean methodologies at SNEF Brasil and other construction companies seeking to improve project management processes:

- **Expand Digital Integration**: As demonstrated by the benefits of automating the Relatórios Diários de Campo (RDCs), further digitalization of project management tools would enhance the speed and accuracy of data handling. Implementing integrated project management software that connects all stages of the workflow—from on-site data collection to final reporting—would reduce manual errors and improve communication between teams.
- **Develop a Continuous Improvement Culture**: While Lean tools such as VSM and 5S provide immediate operational benefits, the long-term success of Lean initiatives relies on fostering a culture of continuous improvement. This can be achieved through ongoing training programs, regular reviews of processes, and involving employees at all levels in identifying areas for further enhancement.
- **Enhance Data Management Practices**: Given the critical role of data in construction project management, SNEF Brasil should continue to refine its data management practices. Standardizing data entry across all projects and improving the traceability of information will lead to more accurate project analysis and better resource allocation.
- **Leverage Industry 4.0 Technologies**: The integration of Lean methodologies with Industry 4.0 technologies—such as automation, real-time data monitoring, and advanced analytics—presents a significant opportunity for construction companies. By incorporating these technologies, SNEF Brasil can enhance its ability to respond to changes in project conditions, improve decision-making, and drive further productivity gains.

6.4 Future Research Directions

Future research should focus on exploring the long-term effects of Lean implementation in the construction sector, particularly in relation to digitalization and data management. Additionally, studies could investigate the potential for combining Lean methodologies with other frameworks, such as Agile project management, to create hybrid approaches tailored to the specific needs of the construction industry.

Another promising area for future research is the application of Lean 4.0, which integrates Lean principles with Industry 4.0 technologies. Investigating how advanced tools such as artificial intelligence, machine learning, and predictive analytics can complement Lean's focus on waste reduction and continuous improvement will be crucial for organizations aiming to stay competitive in an increasingly digital world.

6.5 Conclusion

In conclusion, this thesis has demonstrated the significant potential of Lean methodologies to improve data management and project productivity in the construction industry. By implementing tools such as VSM and the 5S methodology, SNEF Brasil was able to reduce inefficiencies, enhance communication, and foster a culture of continuous improvement. While challenges remain, particularly in the areas of cultural adoption and data management, the findings from this research highlight the adaptability and value of Lean principles in modern project management. With further digital integration and a commitment to continuous improvement, SNEF Brasil and other companies in the sector can continue to benefit from Lean methodologies in the years to come.

REFERENCES

MILETIĆ, Marko; MILETIĆ, Ivan. Lean methodology and its derivatives usage for production systems in modern industry. *Applied Engineering Letters*, v. 2, n. 4, p. 144-148, 2017.

GIL-VILDA, Francisco; YAGÜE-FABRA, José A.; SUNYER, Albert. From Lean Production to Lean 4.0: A Systematic Literature Review with a Historical Perspective. *Applied Sciences*, v. 11, n. 10318, 2021. Available at: https://www.mdpi.com/journal/applsci. Accessed on: 05 Sep. 2024.

PETTERSEN, Jostein. Defining Lean Production: Some Conceptual and Practical Issues. In: *11th QMOD Conference - Quality Management and Organizational Development: Attaining Sustainability From Organizational Excellence to Sustainable Excellence*, Helsingborg, Sweden, 20-22 August 2008.

PASQUALINI, Fernanda; ZAWISLAK, Paulo Antônio. Value stream mapping in construction: a case study in a Brazilian construction company. In: *IGLC-13 Conference*, Porto Alegre, Brazil, 2005.

UGHETTO, Pascal. Comprendre le Lean pour mieux le maîtriser. *Soins Cadres*, v. 29, n. 118, p. 9-14, 2020.

GIAMPIERI, M. Impact of Industry 4.0 management systems on lean production. *Università Politecnica delle Marche - Facoltà di Ingegneria*, 2020.

OLIVEIRA, Samuel et al. Implementação da metodologia 5S e suas influências positivas quanto sua aplicação nas indústrias, um estudo de revisão bibliográfica. In: *XXXVIII Encontro Nacional de Engenharia de Produção*, Maceió, Alagoas, 16-19 Oct. 2018.

GARNIER, David. La Value Stream Mapping: un outil de représentation des procédés et de réflexion pour l'amélioration Lean appliquée à l'industrie pharmaceutique. *Thèse de doctorat en pharmacie*, Université Joseph Fourier, Grenoble, 2010.

HOHMANN, Christian. Guide pratique des 5S et du management visuel. 2nd ed. Paris: Éditions d'Organisation, 2010.