TÉCNICO LISBOA

Process efficiency improvement at a company operating in the repair and maintenance of vehicles – Application of the Hoshin Kanri methodology

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Abstract - Over the last few years, in line with the globalisation process, the markets became more competitive than ever before. This scenario forced companies to review their business models, in order to be able to offer a wide range of products with high quality at a low cost. In this context, many companies have been adopting lean strategies focused on reducing waste through continuous improvement to achieve better results with fewer resources and thus succeed in the more competitive market. Company X – dedicated to the repair and maintenance of vehicles - contacted the Kaizen Institute to review its strategy and improve its operational processes. To accomplish this objective, a literature review was carried out on the topics of lean. Based on the literature and the knowledge of the As-Is processes, a methodology was developed. The methodology is composed of a strategic application component, through the Hoshin Kanri methodology, and an operational application component, based on lean concepts. As procedural improvements, a new layout for the workshop was implemented, the workshop teams were dimensioned, a planning tool was created, and new value streams were developed in the workshop. The main results obtained with this work were the increase in the overall productivity of the workshop in Zone A from 60% to 73% and the increase in the level of service from 61% to 71% between January and June 2019. Finally, some conclusions are drawn, and it is recommend to replicate these alterations to the other workshop of the company.

Keywords: kaizen, lean, Hoshin Kanri, workshop, efficiency, lead time, jobshop

1.Introduction

The contemporary economy has been characterised by increasing globalisation, creating conditions for the increase of world trade, reducing barriers and exposing national markets to a wider and more competitive market.

This competitiveness is a result of the ease access to information that made the consumers more demanding in terms of quality, low prices and convenience. (Taylor & Storch, 2011). This picture creates a series of struggles in companies that in order to remain competitive are forced to increase the offer and quality of products/services and keep low prices. The key to achieve this is the efficient management of resources and increase productivity, e.g, product more with less (H.-L. Wang, 2014).

In this context, many companies have adopted lean strategies, focused on eliminating waste through continuous improvement to achieve better results with fewer resources and this prosper in more competitive and globalised markets (Abdulmalek & Rajgopal, 2007).

This paper consists in a practical case study of the application of lean methodologies to a Portuguese company, Company X, that operates in the transportation industry. The main objectives are: design a new strategic vision aligned at all levels of the company – strategic, tactical and operational – using the Hoshin Karin - and improve the operational flows at a workshop by using Total Flow Management and Value Stream Mapping.

2. Case Study

2.1. Company X

Company X was founded in 2006 and belongs to a national group, Group Y, which is leader in the logistics and transportation sector in Portugal. The latter is structured into two business areas: the core business, which includes logistics and road freight transport companies; and the complementary activities, in which Company X is included, and which represent activities to support the core business, such as the sale and rental of vehicles for the transportation of goods, and repair and maintenance of vehicles.

Since its foundation, Company X has suffered several adjustments in its business model to offer a wider range of services, namely, sale and rental of heavy vehicles, sale of parts and workshop services - of high quality at competitive prices. Furthermore, today, besides providing support to the companies of the group it also sells its services to external clients being an autonomous company. Company X has a workforce of around 100 employees and has facilities in two parts of the country, Zone A and Zone B.

From the start, Company X has shown healthy growth, with a greater number of international partners, a continuous increase in sales and a wide range of customers. In order to keep growing, Company X decided to hire Kaizen Institute to review the strategy and internal processes in order to improve its productivity.

2.2. Workshop Division

Company X's organisational structure is represented in Figure 1. It is divided into seven departments, all under the coordination of the general director.

Figure 1 Organisational Structure of Company X

The names of each division are self-explanatory. The present work focuses on the Workshop Division, more specifically at one of its workshops, Workshop A. From now on, the latter will be referred to as "WD".

WD is responsible for the services offered at the two workshops of the company, located at zone A and zone B. This management encompasses the reception of vehicles and first contact with the customer, the planning and sequencing of the work to be carried out on the vehicle and the operational control of the provision of repair and maintenance services.

The type of vehicles that request this type of services are varied from trucks, trailers, semi-trailers, tractors and buses. This variability implies a high number of parts and consequently higher stock levels. It also requires extensive technical knowledge associated with the specific circumstantial needs of heavy vehicles.

The main goal of the WD is the satisfaction of its clients achievable by high expertise, competitive prices and meet the deadline established. However, the last company's results were under the goals defined. For this reason the company decided to hire the Kaizen Institute in order to help them to reach the goals established.

2.3. Workshop A

The layout As-Is of Workshop A is illustrated in Figure 2.

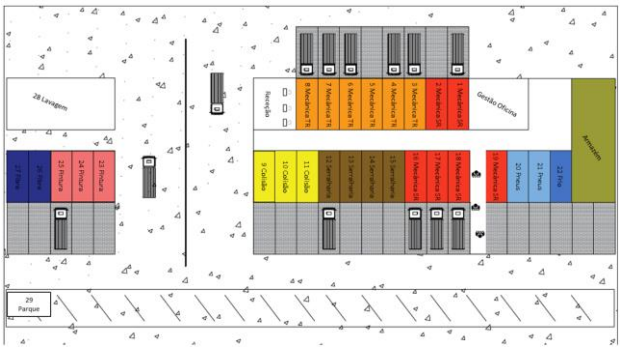

Figure 2. Layout As Is Workshop A

As can be seen in Figure 2, the workshop layout is visually divided in sections, each one responsible for different tasks. Each section is then divided into boxes. For example, section "Mecânica SR" has six boxes.

Each section is autonomous and has a dedicated team led by a team leader (see Table 1). This means that if a truck has to be painted, change the tires and washed needs to travel between the respective sections. The travel time between each section is waste.

Table 1. Number of employees per section of the Workshop A

Section	Number of employees
Pintura	2
Mecânica TR	11
Fibra	6
Mecânica SR	12
Serralharia	11
Frio	4
Lavagem	1
Colisão	6
Pneus	2
Total	55

In order to understand all processes since a vehicle arrives until it leaves the workshop is important to describe the material flow, information flow and the parties/areas involved– see Total Flow Method in Section 3.3.

The material flow and information are depicted in Figure 3 and 4, respectively. The commercial division manages the car fleet of the Company X and the requests from partners. As for, punctual services, the vehicles go directly to the workshop without having to contact the commercial division.

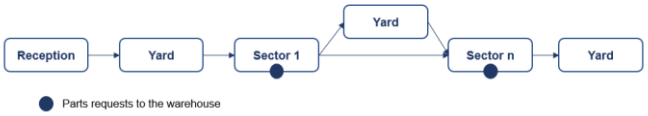

Figure 3 Material Flow at Workshop A

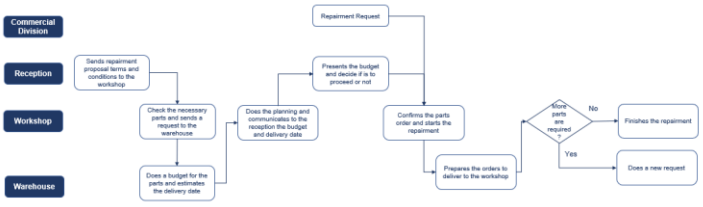

Figure 4 Information Flow between the different parties involved

In terms of material flow, the vehicle first goes to the reception to do the check in. The check in includes a visual inspection of the vehicle that aims to gather the repair needs. This process is not meticulous and usually fails to identify the problems since the reception team is not expert. Then the vehicle waits at the yard until one of the sections is available to start the repairments.

When the vehicle enters the one section a new and this time rigorous inspection is done to diagnose the needs of repair. The flow between sections depends on the needs of the vehicle and its availability. Therefore, after finishing at one section, the vehicle will move to next section (if it is free) or to the yard again (in case it is not free). The requests for parts are done at each section.

In terms of information, the reception lists all the necessary operations to be performed by the workshop and then sends it to latter. The workshop is then responsible to answer with the estimated starting date end date and the repair budget – labour costs plus parts' cost. The parts' requests are done to the warehouse by a computer.

There are several problems with the As Is material flow and informational flow. The first one is the **lack of planning** since there is not any tool to assist the estimation of the repairs neither any sequence between the different sections is not established. This leads to high lead times and frequent delays (53% of the repairs in 2018). Considering that client satisfaction is the major goal of Company X, this problem is very important.

In addition, the material flow – flow followed by one vehicle – **is not structured.** This results from (1) dedicated resources together with the variable workload per section causing an imbalance between capacity and workload and (2) bottlenecks caused by long waiting times by the warehouse which is not organised. This bottleneck is amplified by the last-minute orders to the warehouse.

The warehouse has another problem related with the stock. Basically, **most of the stock are slow movers** that do not fit most of the recent vehicles due to technological advances. Therefore, the warehouse is full of this stock which turns it inefficient and there is not stock of the most popular parts, so the workshop is dependent of the suppliers' lead time.

3. Literature Review

3.1 Lean thinking

In the literature, there are several definitions of concept of lean thinking. Some are more inclusive and others more specific but its consensual among the literature that lean thinking focuses on the elimination of waste, e.g, non-value added activities.(Abdulmalek e Rajgopal (2007), Boyle e Deflorin (2009)). Lean thinking is based on three fundamental principles: the creation of value, the elimination of waste and creating flow.

There are seven different types of muda (waste) (Melton, 2005; Suárez-Barraza, Dahlgaard-Park, Rodríguez-González, & Durán-Arechiga, 2016): (1) excessive production; (2) movement of material between places does not create value for the final customer; (3) waiting material; (4) movement of people – excessive movement of people is a result of an inefficient process or layout; (5) workers waiting to interview in the process; (6) over processing, and (7) errors.

At an early stage of improvement, waste is easily identified and eliminated from the value chain, creating an impact on cost reduction. As processes become more efficient, with companies having the ultimate goal of implementing processes free of any type of waste, the elimination of changes will be increasingly incremental (Melton, 2005).

Lean and kaizen are commonly confused. Lean, as reviewed in this section, is about eliminating waste. This is done through continuous improvement (kaizen). One can then interpret lean as the desired result, the ambition of the perfect state without waste, and kaizen as the way to get there, the continuous cycle of improvement that is at the heart of lean thinking (Melton, 2005).

The application of lean thinking can be divided into five steps (Nelson, 2016): (1) Identification of **value**, (2) Definition of the **value stream** (3) Creation of **flow** (4) Production in **pull** (5) Search **perfection**.

3.2. Lean Methodologies

Pull Planning

Pull planning methods are based on real consumption, meaning that only consumption generates production, leading to flow optimisation, reduction of cycle time and work in progress, and elimination of non-value added activities (Hopp & Spearman, 2004)**.** Whereas, push planning methods are based on demand forecasts, which are uncertain. To cope with this uncertainty it promotes large amounts of safety stock, thus, not optimising resources (P. Sen Wang et al., 2018). Commonly, pull production systems use **Kanban** to control the work in progress.

Hoshin Kanri

Hoshin Kanri (HK) was created in Japan and is an amalgamation of the Japanese terms Ho, Shin and Kanri. Ho means "Method" or "Form", Shin means "Compass" and Kanri means "Management" or "Control". Its composition can be interpreted as "methodology for defining strategic direction" (Kaizen Institute, 2018).

It consists in a management framework that aims to improve the communication, prioritisation and alignment within an organisation, thus increasing the effectiveness of strategic planning and the reach of outlined objectives. This is accomplished by involving leaders in the operational decisions that must convert the strategy into action, and through the integration of the organization's employees in the design and path of the vision. (Charles & Paul, 2001; Found & Bicheno, 2017).

HK can be divided into two phases: hoshin planning and hoshin review. The first consists in the development of a strategic vision for the company and settlement of

priorities. The second consists in a critical review of the goals established, progress completed and changes to the plan (Bastos & Sharman, 2018).

3.3. Lean Tools

The literature is reach in lean tools, however, for the present work two were considered especially relevant: Total Flow Management (TFM) and the Value Stream Mapping (VSM).

Total Flow Management

TFM consists in the development of a flow of materials and information over the value chain so it encloses the entire logistics – internal and external – and production. For each of this axis there are specific tools to develop the flows which are depicted in Table 1.

Table 2 TFM Model

Production Flow	**Internal Logistics Flow**	**External Logistics Flow**
Layout and Bo rder lines	Supermarkets	Warehouse Layout
Standard Work	Mizusumashi	Milkrun
Smed	KB/KJ	Inbound and sourcing
Automation of low cost	Pull Planning	Outbound and delivery

Value Stream Mapping

When seeking for muda and improvement opportunities, VSM is a powerful tool that consists in the visual representation of all flows at value chain. It aims to identify all types of muda and find solutions to mitigate it. It is composed of four steps: (1) Selection of the product (2) Map the As-Is Situation (3) Map the future vision (4) Reach the future vision (Rother e Shook (2003)).

3.4. Lean in Workshop Operations

The concept of lean remanufacturing is one that falls within the scope of the case study. In the literature, remanufacturing is defined as the process that brings used products back to useful life.

Some authors claim that it is difficult to apply lean principles in remanufacturing. Others, that explore its application mention that the biggest challenges are in the fall into the following axis: product quality, process lead time, and inventory levels. They also defend that the advantages of applying lean in this context outweigh the disadvantages and that, despite the difficulties, they allow companies to improve business indicators (Kurilova-Palisaitiene and Sundin (2014)).

Jobshop is other lean concept that fits the case study in hands. It is characterised by the reduced volume, high variability of work and by a fixed layout where the product is fixed and the employees move around to get the necessary tools and parts, to carry out the value-added activities. In order to avoid this, skilled, versatile and flexible works are needed (Haider & Mirza, 2015).

4. Methodology

Based on the literature review, a methodology composed of lean tools and methodologies was developed for Company X. Rather than used isolated, the concepts were integrated as depicted in Figure 5.

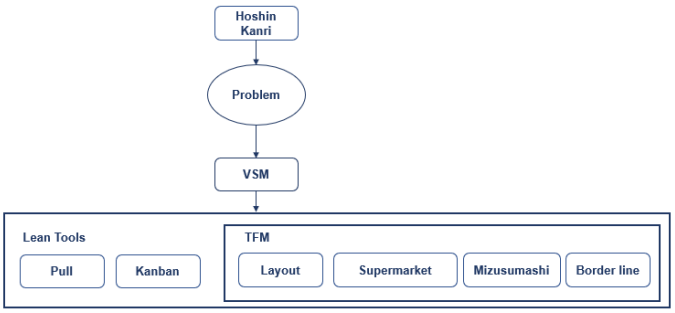

Figure 5 Methodology applied to the present case study

4.1. Strategical Planning for Company X

In recent years, Company X has had satisfactory financial results, but still under the goals settled. For this reason, together with the KI, Company X decided to apply a new management methodology – HK - to define a strategic vision for company and enhance its implementation. Recalling that HK is a methodology to align all organisation to work towards the same goals.

The reasons behind the choice of HK are: (1) company has not be growing has desired and, (2) ambitious goals were settled, (3) HK also reflects on the main causes for not achieving the results settled and (4) break the distance between the top management decisions and the other levels of management.

The main goals established were an increase of general productivity of the workshop from 59% to 90% and increase of service level from 53% to 80%.

4.2. Value Stream Mapping for Company X

Recalling that the VSM consists in the visual representation of all processes in the value stream and classification as waste or value added.

Selection of a product/family of products

The flow unit is the vehicle since is the product to be repaired in the workshop and on which value-added activities are carried out. The value stream is the sequencing of value-added work done on this flow unit. Note that, whenever this flow is stopped, waste is accumulating in the process. The VSM aims to reveal all this existing waste, so that, through the implementation of improvements, it can be eliminated.

As Is Mapping

The As Is mapping is an exhaustive phase of the VSM that required a continuous presence on site (gemba) to gain deep knowledge about each phase. As previously mentioned, the main goal of this phase is to identify improvement opportunities to reduce waste. Therefore, the exhaustive description of each process is not here presented – a lighter one was already provided - , rather this part focuses on the improvement opportunities found during this exercise. Those are listed underneath.

(A) Two distinct repairment types – one simpler and faster and does not require expertise work and on the opposite, a flow more complex and resources consuming. For both jobs the plan is equal and there is not a prioritisation of faster jobs
(B) The travel distance that vehicle does by changing through each section and from the yard to the workshop are non-value added activities
(C) Dedicated resources per section that do not flow or change between sections causing bottlenecks
(D) Lack of accuracy at the initial inspection
(E) The team leaders have excessive tasks without added value for example picking up the parts at the warehouse and going to the yard
(F) Lack of safety stock at each section to be less dependent on the warehouse
(G) Poor planning of the stock of the warehouse
(H) Lack of performance indicators or standards of productivity to reach
(I) The information flow among the value chain is not agile

To Be Mapping

Every modification here mentioned contributes to achieve the goals defined by the Hoshin Planning (see Section 4.1.) more specifically, reduce waste and as a result an increase productivity, reduce the lead time of repair and increase plan compliance. The modifications are listed underneath.

(1) Organise the workshop into two value streams, each dedicated to one of the two existing types of repairs. Thus, there is now the stream of small works (SW) - repairs less than 5 hours of work and that do not undergo painting - and the stream of large works (LW) - repairs greater than 5 hours of work or that include painting work . For each value stream the vehicle follows a different path.
(2) For the SW, and considering the improvement opportunities B and C, there are no longer fixed resources per section, which are now fixed to the SW stream. Employees are trained to carry out all types of different repairs. Vehicles wait in a buffer dedicated to SWs and are taken to a dedicated box by order of arrival (FIFO). Note that this change also required an alteration of layout (see Figure 6).

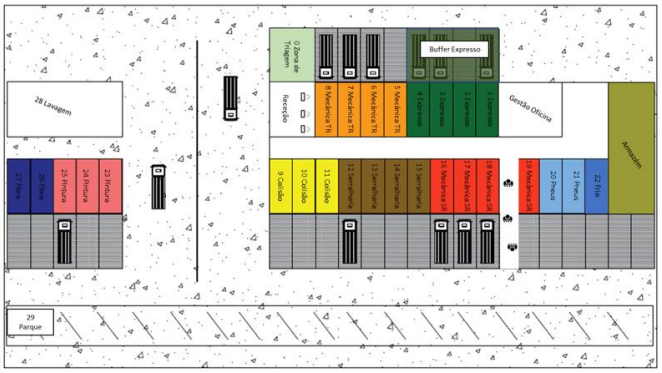

Figure 6 Layout to Be Workshop A

The major differences between this layout compared to the layout As Is are the expresso section, the expresso buffer and the sorting area. The expresso section is the area dedicated for the repair of SW, the buffers is a waiting area for the SWs. The sorting area is explained further.

(3) Inclusion of a zone of sorting labelled with 0 in Figure 8 to a proper inspection of the vehicle. This change is related with the improvement opportunity (D)
(4) Each section will have stock of some of the most popular parts to avoid the waste associated with the order to the warehouse. This action copes with the improvement opportunities E and F
(5) Implementation of the "Daily Kaizen" which aims to structure the team meeting and do daily status about the main indicators. This is linked with H and I

From As Is to To Be: Action Plan

The Action Plan consists of specific actions to be followed and the KPIs to be followed. In addition, it is also defined a primary responsible to follow the Action Plan and a document review date.

For example, for the value stream organisation the KPIs established were number of repairs per week, average lead time per repair. As regards the sorting area, the KPIs were number of orders per section, lead time between the first and last order, number of travels to the warehouse.

5. Implementation and Results Analysis

The implementation of the Daily Kaizen aims to drive a continuous improvement culture at the workshop. Daily kaizen helps to make small improvements in the short term and allows sustaining improvements over time. Furthermore, it motivates the teams and makes them capable of implementing improvements autonomously in the long term, without the need for monitoring by the KI or any other external entity.

At the workshop A, it was implemented a dynamic of daily meetings at the beginning of each day. The meetings lasted 30 minutes and took place around a

framework based on the principle of visual management and the participants remained standing while participating in the team. The meeting leader is the same person responsible for the planning of the workshop, whereas the other participants were the team leaders and the employees of all sections.

The dynamics of the meeting were structured in three key moments: 1) work planning, 2) monitoring of indicators and 3) improvement cycle. At the time of work planning, the repairs planning for the workshop was globally reviewed and a status assessment was made of the estimated delivery times for the pending parts. During the monitoring of indicators, the workshop's business indicators were updated and discussed. At the end of the improvement cycle, the main deviations from the indicators were analysed, concrete actions were planned, and some outstanding issues were discussed, and good practices were shared.

In order to assess the success (or not) of the Daily Kaizen, audits are scheduled to the meetings, the board and to the knowledge of the employees. Two audits are performed by the KI, in the end February and July of 2019. The results are depicted in Figures 7 and 8.

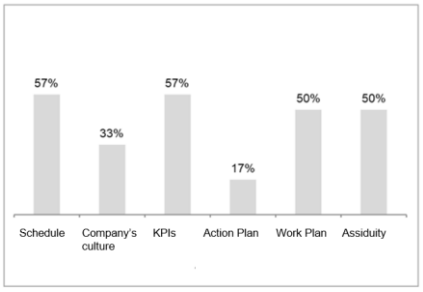

Figure 7 Results audits to the Daily Kaizen on February of 2019

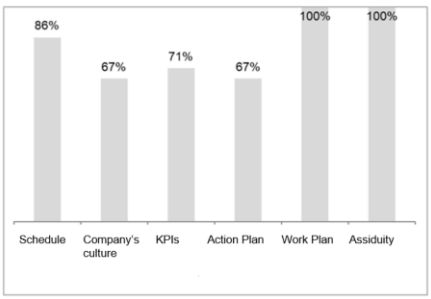

Figure 8 Results audits to the Daily Kaizen on July of 2019

From the figures above is possible to see a significant difference in the results from both audits. Furthermore, the workshop also felt several improvements as facilitation of problem solving, better communication between each section, motivation of the employees and better planning of the services provided.

As regards the SW, after the learning period, a significant increase in productivity was reached at for the SW flow as can be seen in Figure 9.

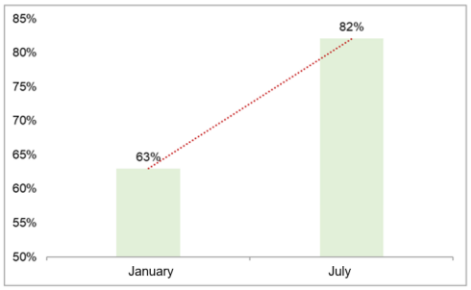

Figure 9 Productivity of the SW flow in January and July of 2019

Despite the solution's success, some difficulties were encountered during its implementation:

1. The training of employees was a key point. The Express section is a multidisciplinary section, in which your employees must be able to carry out any repair task to an SW and there must be no specialized work within the section. This way of working was not easy to implement, as employees came from different sections and naturally had a more focused experience in certain types of work. Over time, training was given to employees and knowledge was shared within the section team, which allowed the multidisciplinary approach to evolve.
2. At the beginning of the implementation, the inspection was still lax which led to wrong assessments and it was common for SWs to become LWs because new repair needs were discovered late. As the implementation of the 6.5 "Dynamic Screening" solution progressed, the accuracy of the inspection improved, which meant that post evaluations and changes from SW to LW flow were reduced.
3. Standard budgeting has changed over time. Initially, the price list did not contain various work rates to be applied to the vehicle. In these cases, and to help with the preparation of the budget, section heads and warehouse employees were contacted by reception. With the accumulation of SW repairs, quotes were added to the price list.
4. FIFO sequencing was not always followed by employees of the Expresso section when collecting vehicles from the waiting buffer. Employees tended to collect first the vehicle that was closest or that had a set of quickest repairs.

Unlike the SP, the planning of the LWs did not suffer a complicated phase of adaptation as the processes were basically the same, but carried out in a more organized and aligned way between the different stakeholders. Early on, the planning dynamics began to yield results, albeit slowly and with a milder peak of improvement than the peak of SW.

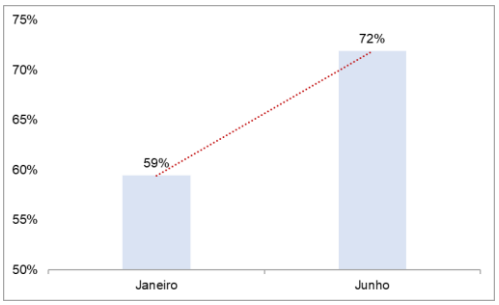

Figure 10 Productivity of the LW flow in January and July of 2019

6. Conclusions and Future Work

Today, the markets are characterised by growing competitiveness and more demanding consumers in terms of offering, lead times and prices. greater demand from consumers. These conditions forced companies to review their strategies, with the aim of optimising the use of resources and maximising customer satisfaction. The transportation market, in which Company X is inserted, is also affected by the conditions previously mentioned.

Company X was founded in 2006 and belongs to a national group, Grupo Y, a leader in the logistics and transport sector in Portugal. Company X gives support to the core business of the groups by providing services as repairment of the fleet. Since its founding, Company X has shown healthy growth, with a sustained increase in sales. However, in recent years its growth has fallen short of expectations. In order to review the internal strategy and optimise its resources in order to achieve disruptive results, Company X decided to hire the Kaizen Institute.

The present work was developed in the context of professional internship at the KI and aims to improve the efficiency of one of the company's workshops, workshop A. The inefficiency at this workshop is a result of the lack of planning and lack of continuous flow of the unit of value within the workshop.

In order to reach the proposed objective, intensive investigation was conducted regarding the topics of lean thinking, methodologies and tools and also searching for case studies similar to the problem in hands. The main concepts studied were lean, kaizen and pull planning.

Supported on the concepts reviewed, a methodology was established to solve the problem at hands. The methodology can be divided into two axis of action: strategic planning component - specifically focused on the Hoshin Kanri methodology – and an operational component focused on improving the operations on gemba.

For the latter, a new layout as designed and implemented, the teams were reallocated and tool for planning the repairs was created. In addition, a new value stream was designed and implemented in the workshop.

The main results obtained with this work were the increase in the overall productivity of the workshop in Zone A from 60% in January 2019 to 73% in June 2019 and an increase in the service level from 61% to 64% in for the same period. The success of the results showed that the methodology developed, based on the concepts studied in the literature review, revealed applicable to the case study of Company X. This reinforces the use of lean concepts and methodologies for workshops.

For future work, it is recommended to replicate the methodologies and reasoning for workshop in Zone B. Furthermore, the success of the methodology requires persistence and the creation of a continuous improvement culture.

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