

Optimization of the Value Chain of the Service Process of the Automotive Mechanical Workshop: Saint Louis T. Through lean tools

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1. ABSTRACT

In Mexico, when we talk about sources of employment, the term of Smes (Small and Medium Enterprises) is well known, since they generate more than 75% of jobs nationwide compared to large companies with only about 25% remaining. Its contribution to GDP (gross domestic product) is currently at least fifty percent, when writing this is clear that they are very important for the economy of Mexico, as well as for people who depend on income from these. When we think about above and we take a look at the current reality in our country we realize that most of the Smes presents a great problem since different studies indicate that they will close prematurely, projecting a life period of 2 to 5 years. It is important to note that both public and private policy do not support or encourage their development will follow this trend. And those people who in a certain moment played the role of entrepreneurs lose their savings and return to look for a job again. In this article we express the concern that we feel for them and we know that they require our support to remain working indefinitely, whereby, we took a look to one particular Enterprise that allowed us to carry out the research project to provide a method of continuous improvement through the Lean Manufacturing Philosophy that allow to optimize the service processes seeking to reduce the time of service (lead time), increase the productivity and on time delivery of the units, generating satisfied customers and reducing costs, which will allow the company to improve its profitability and continue with its operations in an indeterminate manner thus breaking the premature bankruptcy trend described above.

2. KEY WORDS

Lead Time: Time elapsed since the unit arrives for service until it is delivered to the client.

VSM: Value Stream Mapping

Value Stream: Also known as a value chain. Represents all the activities carried out to generate the product or service.

Waste: All the activities that add time, effort, cost but not value.

Smes: Small and Medium Enterprises

Lean Thinking: Is to create value and reduce waste to reduce costs and improve productivity and quality.

Gemba: Knowing the process, observing and verifying it directly without intermediaries, it is necessary to perform Kaizen properly

TT: Takt Time

TPS: Toyota Production System

DAP: Process analysis diagram

LM: Lean Manufacturing

3. THE AUTOMOTIVE MECHANICAL WORKSHOP: SAINT LOUIS T

It was inaugurated in January 2016 by the Owner is by profession Automotive Mechanic Engineer and after having served as Service Manager in a Recognized Car Brand and in order to meet the demand present in the south of Tlaxcala. The company starts as a family business, is located in a municipality of Tlaxcala, Mexico and has administrative and operational areas to cover all the activities from it. The Workshop has an approximate area of 600 m², in addition to starting its operation with a workforce of 12 employees at the end of its first year of creation to make possible the fulfillment of the different labor responsibilities of the company. Saint Louis T is an automotive mechanic workshop dedicated to offering its services to the general public of the different brands and models existing in the automotive market.

4. THE PROCESS OF MECHANIC SERVICE

The service begins when the client arrives with his unit to the company, continues with the respective mechanical maintenance, goes through the washing and finishes with the delivery to the client and billing. The stages that encompass the process are detailed below:

1. Reception: The service starts from the moment the unit arrives at the facilities by the customer or by means of crane service, the owner is questioned about the minors due to the fault and information that can help detect and diagnose the fault quickly, once insurance of the failure is made a budget.

2. Quotation (Total Price of Service): Includes the cost of spare parts and workforce cost. For this, the client is provided with a budget with reactions in which there is a guarantee and which also guarantee the work. If the client does not accept this budget, 2 more are considered upon request:

I. If the customer wants spare parts in particular, the quotation is made but it is indicated that in spare parts of his choice the guarantee is not given in the labor of 2 months that is normally offered.

II. Just in case the client requires it, a third budget can be generated that would be repair or replacement of use. This option is the least recommended to the client because its security is involved.

If an agreement with the quote is reached the next step is purchase of spare parts, otherwise the client withdraws his unit and the process ends.

3. Purchase of supplies (Spare parts, oils, lubricants, auto parts and mechanical parts): Once accepted any of the aforementioned contributions, we proceed to purchase necessary supplies.

4. Mechanical maintenance of the Unit: After the diagnosis is made, it is ideal to start the maintenance so that when the supplies arrive they are replaced. New parts or purchased parts are put into the unit and the

parts of the car that had been removed are assembled or assembled. And finally, the necessary tests are carried out to ensure that the service has been carried out successfully.

5. The Client is informed that his Unit is Ready: A call is made to the client to indicate that the service was successfully performed.

6. Cleaning and Vacuuming: It is offered to all customers as an added value to the service offered. And the customer call starts immediately afterwards.

7. Final Checking: The client is shown that the anomaly has been repaired, sometimes a test is carried out if the client requires it, although the service is guaranteed for 2 months.

8. Invoice and Delivery: When the client gives the approval of his unit, he proceeds to charge the service. If you require an invoice, the corresponding VAT is added.

The guarantee offered is 2 months in labor and 30 days in spare parts.

Forms of payment: cash, check, bank transfer, with 3 and 6 month credit card without interest or debit.

Mechanic Services:

Saint Louis T offers a variety of services and among the main ones are the following:

Table 1. Mechanic Services

✓ Motor adjustment	✓ Levels of liquids
✓ Tune up of motor	✓ Alignment and balancing
✓ Brake system	✓ Clutch change
✓ Suspension system	✓ Change of distribution bands
✓ Lubrication	✓ Diagnoses by Scanner
✓ Maintenance to standard and automatic boxes.	✓ Cooling system
	✓ Hidraulic direction

✓ Clients

Saint Louis T has clients from the public, private and particular sectors. The type of clients is described below:

Public Client: Public corporation, state enterprise or State Corporation is one that is owned by the government, be it national, municipal or any other administrative layer

Private Client: It is a type of commercial enterprise that is owned by private, non-governmental investors

Particular Client: Physical persons that not belong to the government, either private enterprise.

The Public Clients units range from sedan patrols, Trucks f150, managerial units, 3.5 ton trucks and until commercial sedan cars and the like. While for private and particular clients units of different body types are attended, like: Pick up, Coupe, Minivan, Hatchback, Panel trasero, Familiar (wagon station), 4x4, and Sedan too, being this last one the most common attend en the Workshop.

✓ Suppliers

The inputs needed by the SME as spare parts, oils, suspensions, etc., are mostly captured by the Owner and include suppliers from Tlaxcala and also from the state of Puebla. The service at home in Motorcycle that give some parts take up to 3 hours to arrive and for this reason is used when the service can wait, otherwise

the Owner is responsible for the collection in their own unit. Below is a list of suppliers from Tlaxcala and Puebla, although when you the part or piece required is not found, it is bought in Mercado Libre:

1. Auto Zone.
2. California Refractionary
3. Mexico Suspensions.
4. Libra Refractionary.
5. Rolcar Refractionary.
6. María Felix Refractionary
7. Direct in Agencies of Apizaco Tlaxcala of the different brands: Chevrolet, Nissan, Toyota, Honda, etc.
8. Rectified San Cosme
9. The Union Refractionary.

5. GEMBA AND BRAIN STORMING TO DETECT OPPORTUNITY AREAS

GEMBA

It starts knowing the facilities of the company, to become familiar with the process from beginning to end analyzing all the stages, activities and operations of the process from the reception unit until the delivery to the client. That by means of a detailed observation and having in mind lean thinking, areas of opportunity are detected:

- Certain quantity of spare parts, additives without any order or inventory as a surplus of previous services that possibly arose from the periodic volume purchase seeking to take advantage of discounts and obtain a decrease in input costs
- There are also cardboard boxes thrown away, scattered work tools, engine parts or engines throwing oil in some areas where mechanical maintenance is performed, impeding the free flow of personnel and the process itself, increasing the risk of an accident labor.
- Units (cars, vans) occupying space in the facilities stealing space that hinders being able to provide the service to other customers, which translates into economic losses.
- In addition, there are no formal procedures to follow to provide the service and each technician does it differently according to their experience, which causes the service to be extended in most cases.
- The management and administrative activities on the part of the owner are saturated since they include: dealing with the customer, receiving units, picking up parts in the state and outside it, which is counterproductive as new units arrive for possible services, these are removed in his absence so it would be good to start delegating responsibilities.
- Customers from 3 sectors are served, which are Public, Private and Private. The first two require credit service and in most services provided the collection of invoices is extended. The service to individuals is the clients that represent the only source of immediate liquidity to and that can contribute to cushion the offered credits to private and public sectors.
- The cost for Dead Times is not known due to: there is no apparent order in the area of mechanical maintenance and in terms of cleaning it is only done when there is little work, finding the right tools and devices for each job takes time for the present disorder and also due at the distribution of plant that represents long distances to capture them.

All above mentioned causes the service costs to skyrocket and causes delays in the delivery in the agreed time, generating a negative aspect and discomfort in the client. It is intended that with the use of the philosophy of lean manufacturing as well as the tools it comprises, the value chain of the process will be optimized and an improvement in the productivity of the SME will be generated that reduces its costs and increases profits.

BRAINSTORMING

This technique was used to gather main ideas about the causes that generate delay in the service which raise the costs of the same and discomfort in the client, the list is as follows:

- Empirical and different mechanical procedures for each mechanic.
- There are no information meetings where feedback is given to staff.
- There are no incentives.
- Poor motivation.
- There is not a defined Layout.
- The acquisition of spare parts and additives is slow.
- It is not defined who corresponds certain activities.
- There is no staff training.
- The owner's activities are too many which makes it difficult to focus on the planning of your company.
- The daily activity of the company is done without prior planning.
- Long distances to capture tool and refactions which generates dead times.
- No delegation of activities.

6. LEAN MANUFACTURING'S TOOLS & WASTE

✓ *LEAN TOOLS*

1. Mapping of the Value Chain.
2. 5'S
3. Standard Work
4. Single-Minute Exchange of Die (SMED)
5. TPM
6. Kaizen
7. Takt Time
8. Kanban
9. Just in Time

✓ *THE 7 WASTE + 1 CONSIDERED IN LEAN.*

They were defined by Taiichi Ohno within the Toyota Production System as follows:

- 1. Overproduction:** It refers to produce more than the amount required by the customer, to manufacture products before they are needed, that is to produce faster than what is required.
- 2. Overinventory.** It is the excess of raw material, work in process or finished product and its indefinite storage which generates a negative impact on the company translated into storage, transportation, handling or obsolescence costs, being able to suffer damages, hidden quality errors and others. Stock wastage is the result of having more stocks than is needed to meet immediate demand, so if material accumulates before and after the process indicates that the production flow is not continuous.
- 3. Overprocessing.** It is the consequence of subjecting the product to unnecessary processes that do not generate value to the client and for which it is not willing to pay.
- 4. Defective Products.** Are those products that are outside the specifications of the client and therefore do not add value to it. These mean a great loss of productivity since it includes extra work as a consequence of not having correctly executed a process. They generate direct costs of non-quality, consumption of raw materials, labor, reprocesses as well as dissatisfaction on the part of the client.
- 5. Transportation.** It is the unnecessary transfer of raw materials, equipment, machinery and people that does not add value to the product. These unnecessary distances must be eliminated since it generates a cost, increases delivery times and risks of damage.
- 6. Waiting Times.** Time that is lost when an operator waits for his machine to finish the job or operation, or otherwise when the machine stops waiting for the worker to make adjustments or even for both worker and machine to wait for work orders, materials or tools.
- 7. Unnecessary movements.** It refers to unnecessary movements of people or equipment within the area of a process. It is the result of a badly designed layout that forces the worker to make movements that force the normal displacements to have an inadequate position placing at risk the health of the worker and generating an unproductive environment. It should seek to reorganize work stations and staff to achieve a better layout and optimize space and movement.
- 8. Do not take advantage of the Talent, Capacity and Creativity of the people.** In addition to the first 7, it is considered mute to waste human talent, not using the capacity of the staff for the needs of the position or the improvement of processes. The ideas of the members of the organization should be taken advantage of to detect possible changes, the non-involvement of the personnel generates demotivation in the employees, waste of resources and distrust in the improvement systems.

7. THE PROPOSED METHODOLOGY FOR CONTINUOUS IMPROVEMENT TO OPTIMIZE THE SERVICE PROCESS OF SAINT LOUIS T

1. OWNER'S COMMITMENT AND USE OF STRATEGIC PLANNING

The first step in any improvement project is that the owner of the company must assume the role of the leader and realize the need for a change. He must commit to the project because success or failure depends on him as well as on the entire organization. The activities of the Company are carried out with

the occurrence of each day without any previous planning, for which the Owner is proposed to use a Lean strategic planning tool known as Hoshin Kanri to help in the planning of the company.

2. CHANGE OF WORK CULTURE THROUGH TRAINING

Once you have the Owner's commitment, the next step is to train staff about the Lean philosophy to start the transition process. The change of the work culture represents a new way of life and habits that requires breaking organizational paradigms. It should be clarified that "anyone can start the change, the problem is to keep it."

3. SELECTION OF SERVICE TO IMPROVE

It is necessary to select a service from the company to improve it, this service must be vital for the company, which represents losses, poor performance, high costs or higher sales and which, when improved, represents a significant impact in terms of cost reduction, improvement of productivity and profitability of it. At the beginning, the opportunity areas should be observed and identified directly from the process, followed by a brainstorm from the process experts to define a list of causes or factors that affect the performance of the process delaying it.

4. ACTUAL PERFORMANCE

Once the service to which we should focus to improve and apply the proposed methodology is selected, the main causes that affect the performance of the service must be monitored to prioritize them. The current VSM of the process is traced to obtain its performance, that is, the total time of the service. We also draw 2 types of process and operations diagrams to identify activities that represent waste and that should be optimized or eliminated.

5. ANALYZE THE PROBLEM TO IDENTIFY MAIN CAUSES THAT ORIGIN IT

The main causes that affect the performance of the process are identified and the value chain is analyzed in order to reduce the Lead Time to optimize it, also the Takt Time is also calculated according to the service selected to project the increase in annual sales by optimizing the value chain of the process and increasing the units attended annually compared with those that have been attended before the improvement project.

6. PROPOSE LEAN TOOLS TO IMPROVE THE SERVICE

Lean Tools are proposed to eliminate the main causes that delay the service which will allow us to reduce the Lead Time of the selected process thus optimizing the value chain.

7. ACTIONS TO KEEP THE LEVEL ACHIEVED

Recommended actions are recommended so that when implementing the Lean tools to the process they allow to reach and keep the desired level.

8. RESTART CONTINUOUS IMPROVEMENT CYCLE THROUGH THE SELECTION OF A NEW SERVICE TO IMPROVE IT.

Once the service has been improved it is necessary to select a new one, as long as the owner's commitment continues and he is aware of the training of his staff so that steps 3 through 8 are repeated, which gives rise to an endless loop of continuous improvement of the process.

8. METHODOLOGY APPLICATION

1. OWNER'S COMMITMENT AND USE OF STRATEGIC PLANNING. Se debe tener el compromiso del dueño en todo momento ya que el abandono por parte del mismo representa el fracaso del proyecto.

2. CHANGE OF WORK CULTURE THROUGH TRAINING. . You must be trained in the Lean philosophy throughout the project. For which purpose to determine a training program that includes topics and dates.

3. SELECTION OF SERVICE. What was described in the section of step 5 Opportunity Areas of the company in question was obtained through the Japanese Gemba Technique together with the Brainstorming technique developed with experts from the process: Owner, Mechanics, mechanic assistants and administrative personnel. It allowed us to define the main factors or causes that affect the performance of the process delaying the service and so we can focus on working to minimize them, always seeking to achieve the main objective of this work, which is optimize the value chain of the service process to reduce the lead time and get as a consequence a cost reduction of it.

Main factors that delay the service:

- 1. Lack of Short Term Planning.** The Owner performs all management and administrative, some of them are: payment and issuance of invoices, input collection, customer service, distribution of work, external service to engines, grinding discs, grinding heads, alignment, rolling and the rest of activities of the business and as well as the staff are carried out according to what is required without any previous planning .
- 2. Appropriate late diagnosis.** For lack of training or experience in the staff. While in an agency service to correctly detect a fault it takes an hour and 2 to repair it.
- 3. Dead Times.** By not having an order in the Tool and devices, and an efficient plant distribution. You have to determine the cost \$ that represents the SME per unit of time (cost per minute or hour).
- 4. New Models.** Sometimes it turns out that for something as simple as changing a bulb you have to be an expert since it involves disassembling many parts.
- 5. Mechanical Procedures without Standardization.** Each mechanic performs his own procedure according to his experience, including unnecessary activities that lengthen the maintenance time of the unit.
- 6. Acquisition of supplies (spare parts, oils and additives).** The catchment in Refactionaries of Tlaxcala and Puebla and directly in Spare parts of Agencies of the different marks in the locality of Apizaco is realized. In Tlaxcala there is delivery to the client in some Refactionaries but in addition to taking too much to the delivery they have deficiencies in variety. All this is done by the Owner.

7. **Emergency Services.** When this happens, the acquisition of inputs is neglected, and the services provided within the workshop are delayed, because the vehicle is serviced directly at the fault site.

To select the service to be improved, the sales, profits and costs of the company are plotted, which are described below, followed by the corresponding graph:

The first one shows us the annual sales of 3 consecutive years until 2018, we can see that sales have decreased considerably in these 3 years and that if the company continues to go bankrupt as indicated by the studies on Smes that predict them 3 to 5 years of life.

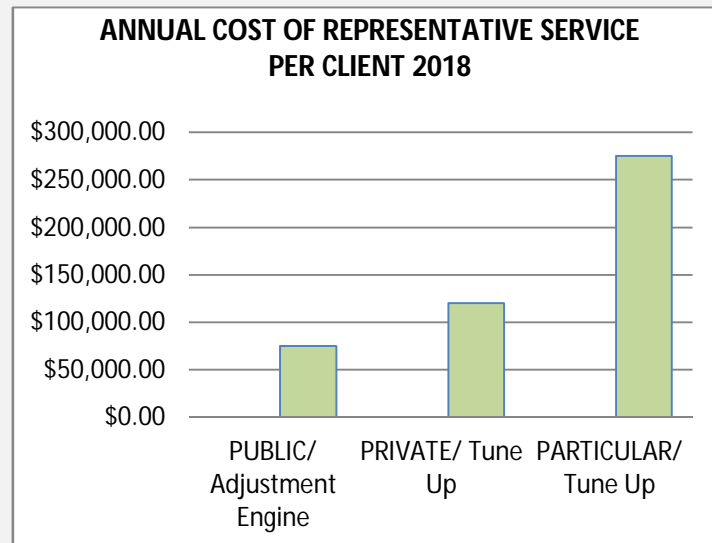
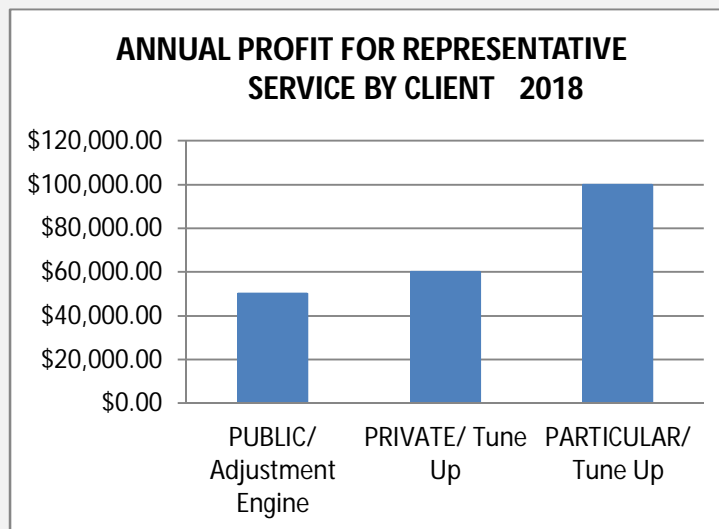
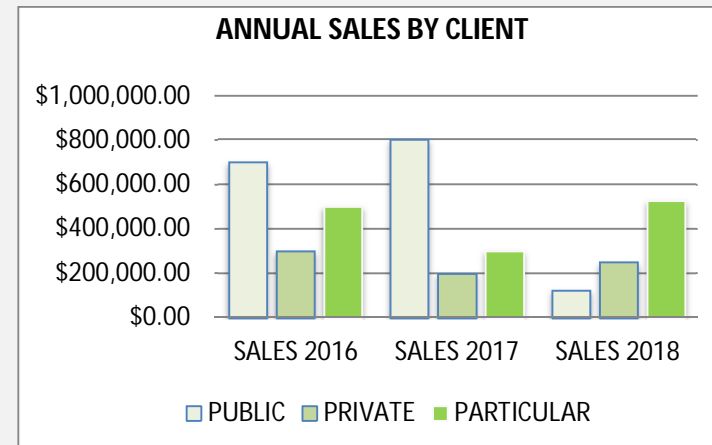
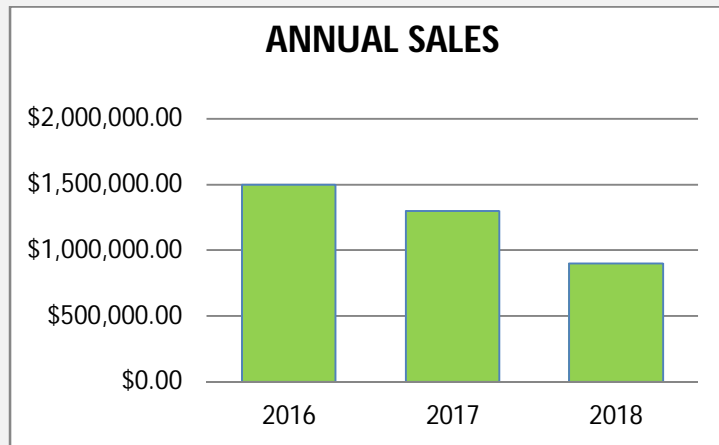
In the second Graph we can see the same sales but according to the 3 types of clients to whom the company provides its services. And we can see that in 2018 private customers are the ones that represent the highest sales and therefore the highest profits.

In the third and fourth graph the profit and costs are presented respectively for each type of client and as well as the service of each most representative client (highest frequency).

In the case of public Clients, the service with the greatest frequency is motor adjustment, while for private and particular Clients the tuning up service latter, which has the highest sales in 2018, as shown below.

SAINT LOUIS T

Figure 1. Saint Louis T. Graphics: Sales, Profit and Cost

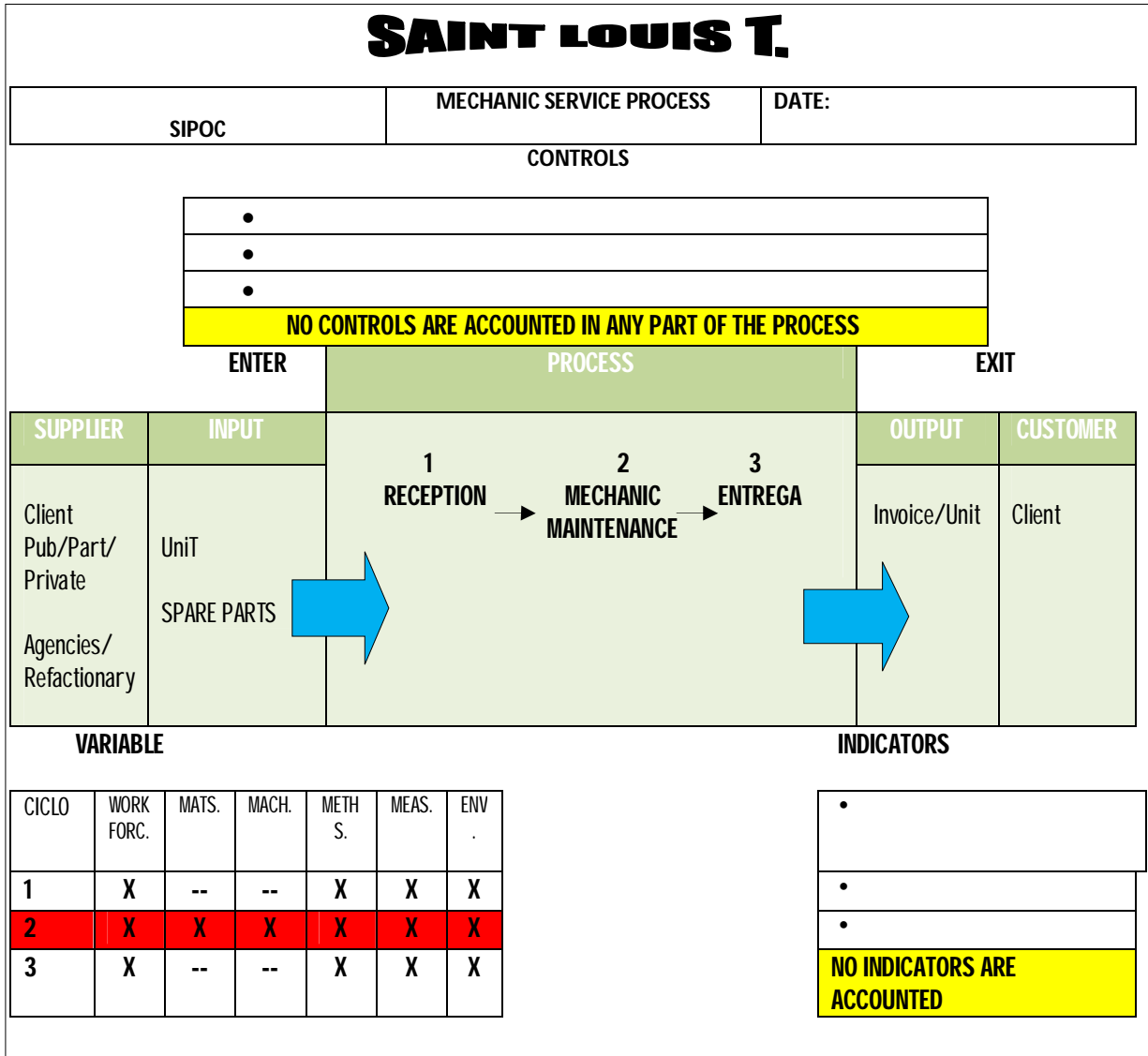


The selected service is **Tune Up of Sedan Autos of Particular Clients** because compared to the other services offered by the SME to different customers this recorded the highest demand and profits in 2018. Sedan cars were selected as they are the most frequent in the SME Tune up. The next step is to measure the performance of the Tune Up service.

SIPOC diagram of the mechanical service

Observe the following flow diagram at a high level which, in turn, will allow us to carry out a detailed flow diagram. Allowing visualize the sequential steps of the mechanical process where we clearly observe its inputs, outputs, suppliers and customers. Showing important details about the beginning and ending of the process.

Table 2. SIPOC



4. ACTUAL PERFORMANCE

To measure the performance of the tuning service, a format was designed to follow up on the activities carried out and obtain the time of each one. The filling of these formats was completed from a total of 79 tunings made in 3 months and the results obtained are shown in the following figure:

Table 3. Lead Time: Tune up service Autos Sedan

NO	PARTICULAR CLIENT	SERVICE OFFERED	M1 (BETO)/ M2 (ALVARO) TIEMPO TOTAL (LEAD TIME) MINS
1	CORREA, MANUEL GUSTAVO	TUNE UP SEDAN AUTOS	220
2	CASTANEDA AYAY, MODESTO	TUNE UP SEDAN AUTOS	215
3	FERNANDEZ, JORGE LUIS	TUNE UP SEDAN AUTOS	236
4	FERNANDEZ, HUGO	TUNE UP SEDAN AUTOS	225
5	HUAMANI MEDINA FIDEL FELIPE	TUNE UP SEDAN AUTOS	236
6	LAZARO VASQUEZ MIGUEL	TUNE UP SEDAN AUTOS	195
7	SARTILLO ROGELIO	TUNE UP SEDAN AUTOS	190
8	LLAULLI RODOLFO	TUNE UP SEDAN AUTOS	190
9	SOLANO CLAUDIO	TUNE UP SEDAN AUTOS	196
10	LOZANO VASQUEZ MANUEL JESUS	TUNE UP SEDAN AUTOS	189
11	SERDAN JUAN	TUNE UP SEDAN AUTOS	196
12	VEGA HIPOLITO	TUNE UP SEDAN AUTOS	200
13	CAMPOS MARCO ANTONIO	TUNE UP SEDAN AUTOS	197
14	PERZ LUIS	TUNE UP SEDAN AUTOS	180
15	PINARES	TUNE UP SEDAN AUTOS	183
16	PINARES EDGAR	TUNE UP SEDAN AUTOS	191
17	CASAS, LAURA GLADYS	TUNE UP SEDAN AUTOS	181
18	PIZARRO JUAN	TUNE UP SEDAN AUTOS	198
19	SEGURA, JOSE	TUNE UP SEDAN AUTOS	193
20	PORTA RICARDO	TUNE UP SEDAN AUTOS	178
21	PRADO KARINA	TUNE UP SEDAN AUTOS	176
22	QUIROZ RAMON	TUNE UP SEDAN AUTOS	187
23	ROSALLES REYNA	TUNE UP SEDAN AUTOS	188
24	RAMIREZ ALEX	TUNE UP SEDAN AUTOS	178
25	RAMOS ALDO	TUNE UP SEDAN AUTOS	187
26	REYNA RAMON, SERGIO ALEXANDER	TUNE UP SEDAN AUTOS	185
27	REYNA VEGA DIEGO	TUNE UP SEDAN AUTOS	182
28	RIOS CASAS HENRY JESUS	TUNE UP SEDAN AUTOS	178
.		TUNE UP SEDAN AUTOS	196
.		TUNE UP SEDAN AUTOS	195
.		TUNE UP SEDAN AUTOS	202
79	MORENO JESUS	TUNE UP SEDAN AUTOS	220

Lead time: process takes an average of 199.9 mins.

Max. Time

Min. Time

We can notice in the previous table that the maximum time recorded is 236 minutes, so the time of each activity of particular client for tune up service was recorded in order to identify the waste, that is, the activities that do not add value, the list obtained with the corresponding associated time is the following:

Table 4. List of activities of the Actual Performance of Tune Up Service Particular Client Sedan Autos

PROCESS STAGES	OPERATIONS / ACTIVITIES	TIME (Mins)	%	TIEMPO OBJ. (Minutes)	
1. RECEPTION	1 Receive unit: take note of customer requirements.	4	1.69%		
	2. Prepare quote	4	1.69%		
	3. Carry out an inventory of available spare parts	3	1.27%		
	4. List of missing supplies (spare parts, oils, additives or parts)	5	2.11%		
	5. Acquisition of supplies by telephone or direct purchase	15	6.35%		
	6. Move unit to maintenance area for service	2	0.84%		
	Cycle Time		33mins	14%	10mins
2. MECHANIC MAINTENANCE	7. Raise unit with hydraulic jack or ramp	3	1.27%		
	8. Capture necessary tools for maintenance service	5	2.12%		
	9. Capture spare parts available from the remainder of previous works	5	2.12%		
	10. Place an oil tank under the Carter	3	1.27%		
	11. Remove Carter Screw and drain oil	5	2.12%		
	12. Put Carter's cap back	3	1.27%		
	13. Remove oil filter	3	1.27%		
	14. Place New Oil Filter	3	1.27%		
	15. Remove Engine oil plug	2	0.85%		
	16. Pour 4 liters of indicated nomenclature oil	5	2.12%		
	17. Check the oil level with the bayonet and add if necessary	3	1.27%		
	18. Inspect for oil leaks and tighten if required	2	0.85%		
	19. Remove used oil tank	3	0.85%		
	20. Lower ramp unit or hydraulic jack	3	1.27%		
	21. Remove gas pump fuse	4	1.69%		
	22. Turn on car to relieve fuel pressure	3	1.27%		
	23. Elevate the unit on ramp or hydraulic jack	3	1.27%		
	24. Remove gas filter	5	2.12%		
	25. Insert a new fuel filter.	4	1.69%		
	26. Put back gasoline fuse	3	1.27%		
	27. Lower ramp or hydraulic jack unit	3	1.27%		
	28. Remove the air filter	4	1.69%		
	29. Place New Air Filter	3	1.27%		
	30. Disconnect wires from the spark plugs	5	2.12%		
	31. Remove 4 Spark Plugs	5	2.12%		
	32. Remove cylinder head cover	5	2.12%		
	33. Calibrate Valves	6	2.54%		
	34. Fit the cylinder head cover by putting silicone on it for sealing	5	2.12%		
	35. Inspect used spark plugs	4	1.69%		
	36. Calibrate new spark plugs	4	1.69%		
	37. Insert new spark plugs with the correct torque	7	2.97%		
	38. Test correct spark plug wires	4	1.69%		
	39. Place Spark Plug Cables	4	1.69%		
	40. Inspect correct order of spark plug wires	4	1.69%		
	41. Inspect fluid levels	5	2.12%		
	42. Fill fluid level (brakes, direction, coolant, windshield)	5	2.12%		
	43. Scan unit to detect any electronic failure	8	3.39%		
	44. Turn on the unit and observe its performance	5	2.12%		
	45. Test vehicle on the road	8	3.39%		
	46. Washing, vacuuming and washing the vehicle engine	12	5.08%		
	47. Inform the client of his finished service	3	1.27%		
	48. Move vehicle to delivery area	3	1.27%		
	Cycle Time		182min	77%	120min
	3. FINAL CHECK, INVOICE & DELIVERY	49. Constatar el servicio realizado con el cliente	11	4.66%	
		50. Facturar y salida del vehículo	10	4.23%	
		Cycle Time		21min	9%
	Total	TOTAL CYCLE TIME (Lead Time)	236min	100%	140min

Let's look at the previous list by plotting the actual VSM of the process:

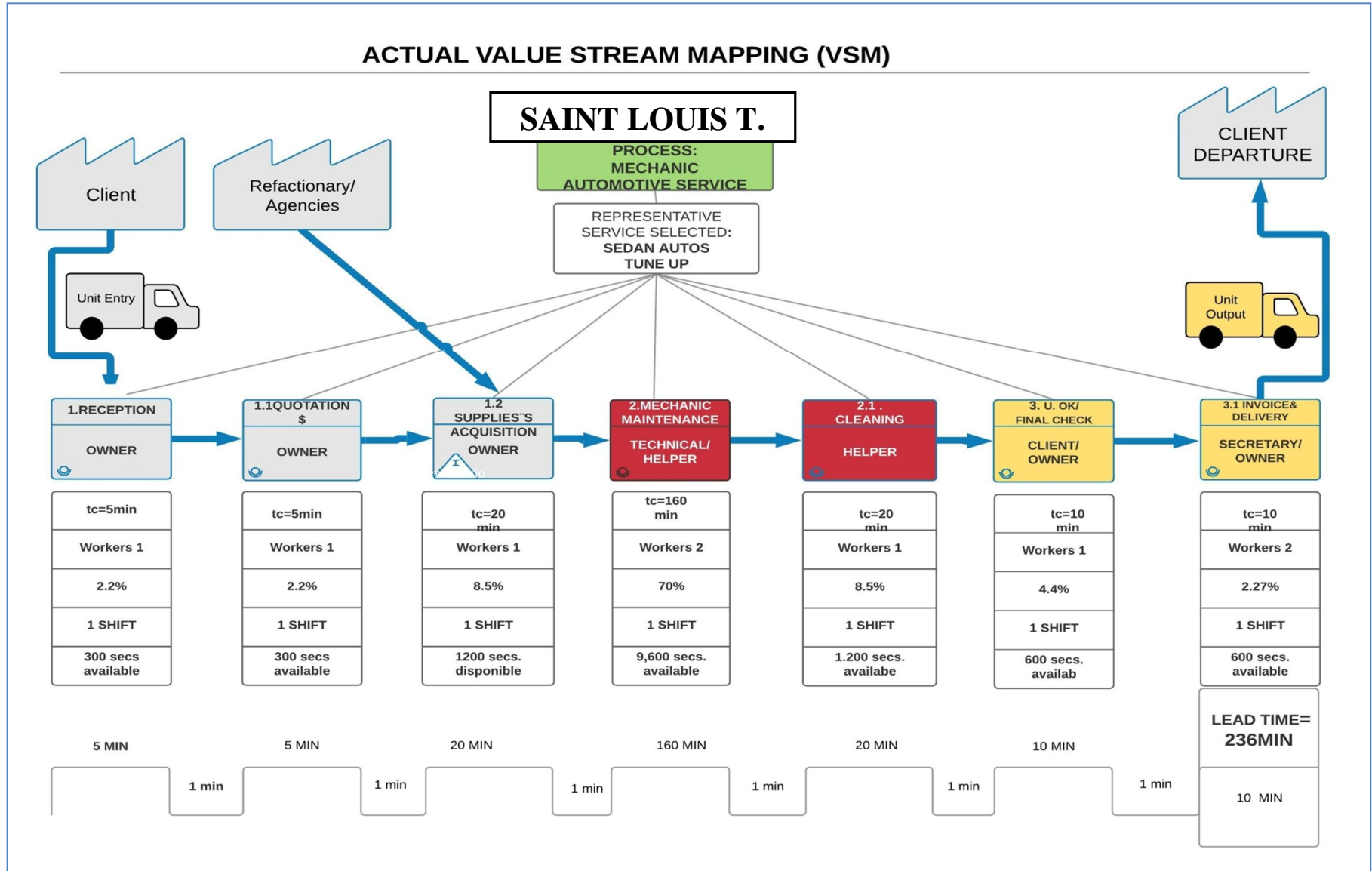


Figure 2. Actual VSM

5. ANALYZE THE PROBLEM TO IDENTIFY MAIN CAUSES THAT AFFECT THE PERFORMANCE

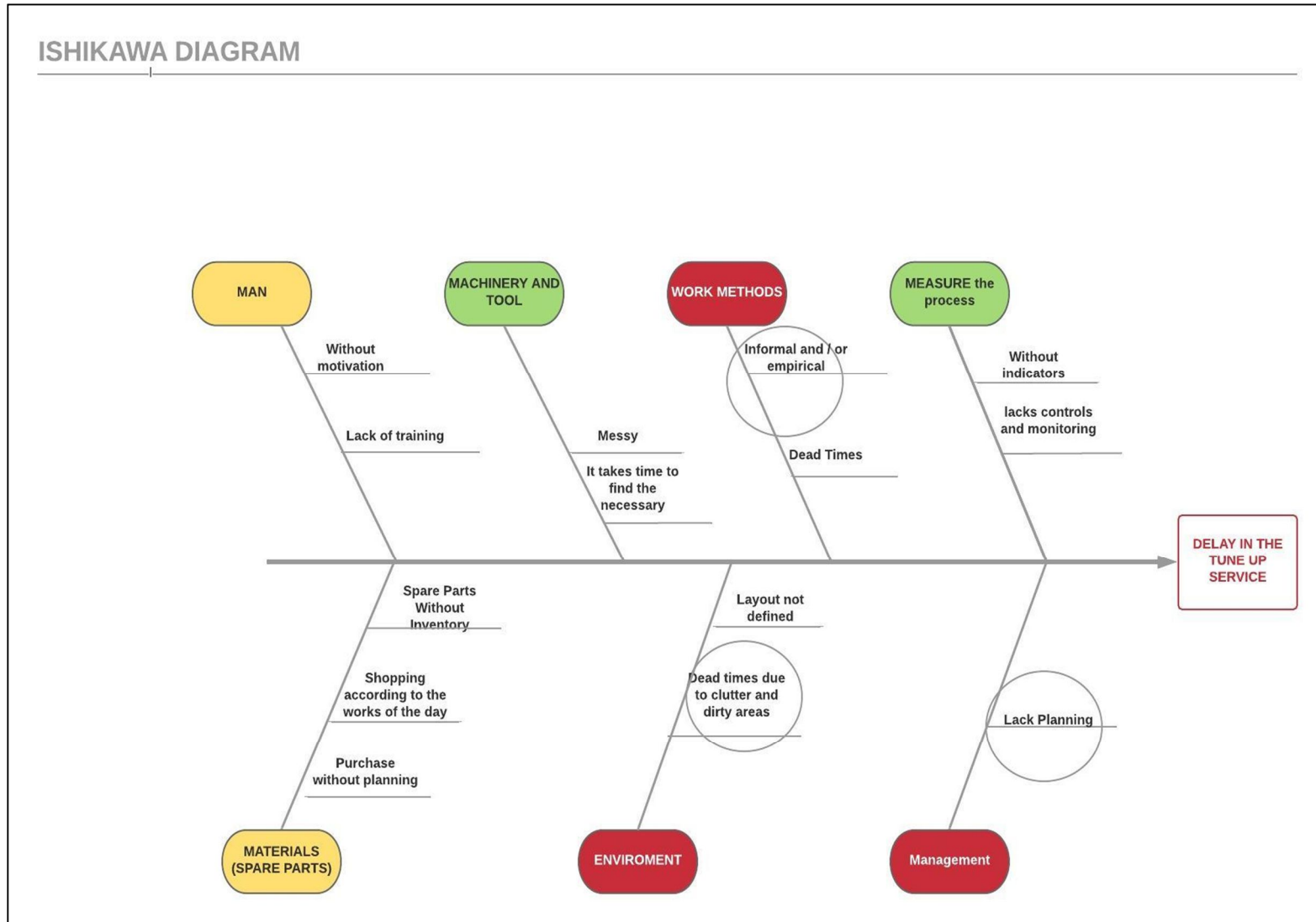


Figure 3. Ishikawa

From the previous Ishikawa diagram together with the Gemba and Brainstorming Techniques, 7 main factors are determined that affect the performance of the service by delaying it. For this reason, these 7 factors are monitored to determine those that are the main ones to attack them through the application and selection of a Lean tool. The monitoring of the factors was done with the help of the verification sheets obtaining the following results:

Check Sheet

Through this tool the frequency of the 7 causes was monitored and that increase the total time of service (lead time). The Service was provided to 57 units in the 5 weeks monitored during the first month at the beginning of the project, belonging to clients of the 3 types that the SME owns: particular, private and public:

Table 5. Causes that delay the tune up service

CAUSES	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	FREQUENCY	PERCENT
1.LACK PLANNING	8	9	11	7	9	44	20.5%
2.APPROPRIATE LATE DIAGNOSIS	2	3	2	2	1	10	5%
3.DEAD TIMES	10	9	12	11	10	52	24%
4.NEW MODELS	3	2	1	1	0	7	3%
5.MECHANICAL PROCEDURES WITHOUT STD	12	11	13	11	10	57	26.5%
6.ACQUISITION OF SUPPLIES	6	5	7	6	8	32	15%
7.EMERGENCY SERVICES	3	2	3	3	2	13	6%
Units per week	12	11	13	11	10	57	100 %

The data of the verification sheet above are presented below graphically for a better interpretation:

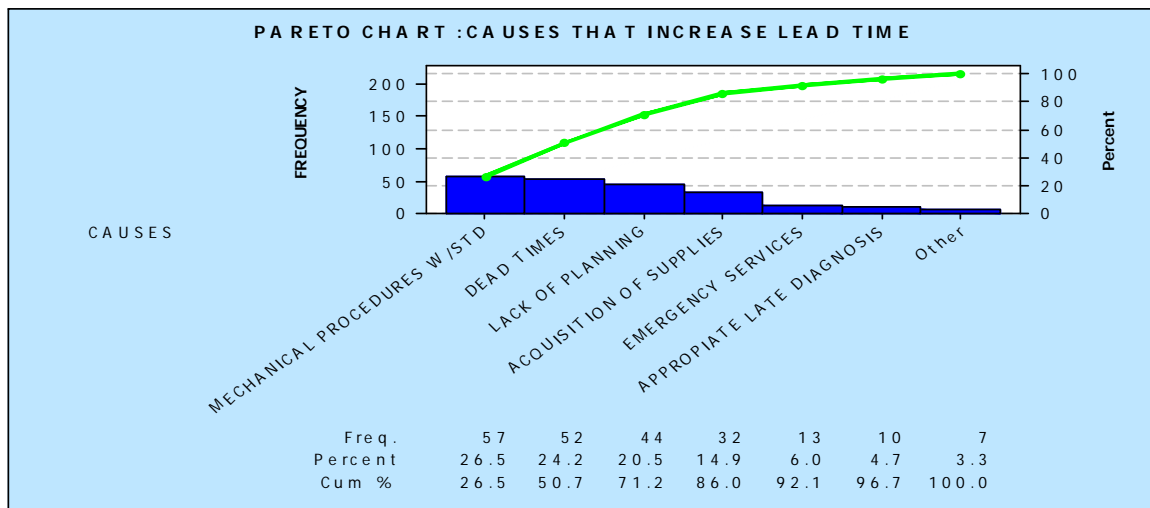


Figure 4. Pareto Diagram

According to the Pareto chart above we can see the 3 most frequent causes that generate service delay:

1. Informal Mechanical Procedures

2. Dead Times by disorder.

3. Lack of Planning

Being the Mechanical Procedures the main cause of service delays. According to table 4, we can see that the stage that represents the longest process time is the mechanical maintenance area:

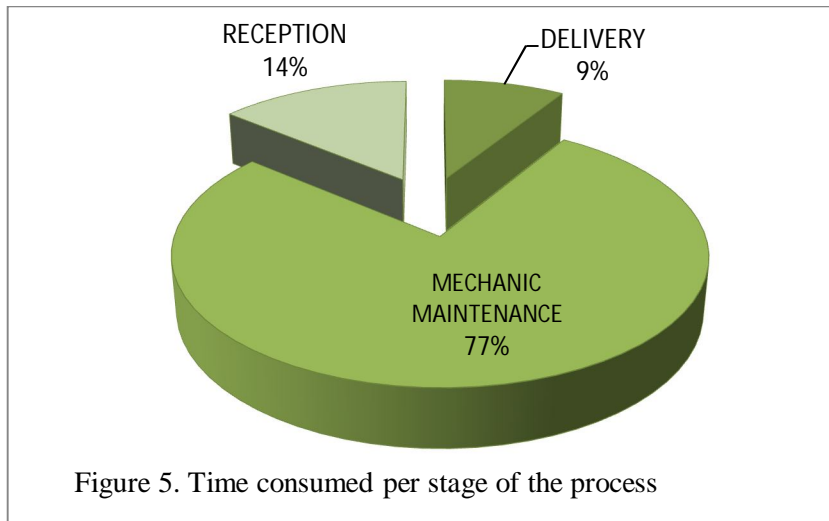


Figure 5. Time consumed per stage of the process

When analyzing the Lead Time of the service we can notice that it is in 236 min, and according to the Labor Guide for Real Time Pro developed by Dowell & Systems, we have that the ideal time for a Tune Up in a body type Sedan is 140 minutes, which compared with companies such as Bosch Service, Nissan and Toyota show the time the same time. Dowell & Systems indicate in their Labor Guide that if our Lead Time in this service exceeds this time, it generates excessive costs and annoyance in the client. Dowell & Systems are experts in times of automotive mechanical services in USA. Observe the times of each company:

Table 6. Lead Time of leading companies in the automotive industry

COMPANY	LEAD TIME
Toyota	120 mins
BOSCH	120-150 mins
LABOR GUIDE REAL TIME PRO	140 mins
Nissan	150 mins
Saint Louis T	236 mins

In order to reduce the total service time by 40%, that is, from 236 to 140 minutes, it is necessary to list all the activities that are carried out to carry out the service and be able to determine which ones represent waste. The Process Analysis Diagram is drawn up in which each activity is evaluated according to the Rother / Shook matrix (2003) to identify waste or activities that do not add value:

Table 7. Evaluation Matrix to detect waste activities

EVALUATION MATRIX		THE ACTIVITY ADD VALUE?	
		YES	NOT
IT IS NECESSARY?	YES	MAXIMIZE	MINIMIZE
	NOT	CREATE NEED TO SELL IT TO THE CLIENT	ELIMINATE

The diagram of analysis of operations and apply the previous matrix to each of the 50 activities (table 4) of the current performance of the tuning service:

Table 8. Process Analysis Diagram (DAP) Tune Up Sedan Autos

SAINT LOUIS T.						
Enterprise: Automotive Mechanic Workshop St. Louis T	Activity	No. Activ.	Time Minutes	Objetive Time per stage		
Responsible: Mechanic Boss	Operation	38	175	Recepción: 10 minutos		
Service: Tune up sedan autos	Inspection	5	25	Mantenimiento Mecánico: 120 minutos		
Fecha de Emisión:	Delay	1	15	Entrega: 10 minutos		
Última revisión:	Transport	3	13			
Elaborated:	Inventory	1	3			
Client: Particulars	Combined	2	5			
	Total	50	236 min			
Etapas: Reception <input type="checkbox"/> Maintnce <input type="checkbox"/> Delivery <input type="checkbox"/>	Area Total Pyme: 568m2		Evaluación			
Actividadesmt	VALUE PYME / VALUE CLIENT	Time Mins.	¿Add value?	¿Es necesario?	Simbol	Action
					○ □ D ↶ ▽ ⊗	
1. Receive unit: take note of requirements		4	No	Yes	○	Minimize
2. Prepare quote		4	No	Yes	○	Minimize
3. Carry out an inventory of available spare parts		3	No	Yes	○	Minimize
4. List of missing spare parts		5	No	Yes	○	Duplicate, link to 3
5. Acquisition of supplies by telephone or direct purchase		15	No	Yes	○	Minimize
6. Move unit to maintenance area for service		2	No	Yes	○	Minimize
7. Raise unit with hydraulic jack or ramp		3	No	Yes	○	Minimize
8. Capture necessary tools to service		5	No	Yes	○	Minimize
9. Capture spare parts available from inventory		5	No	Yes	○	Minimize
10. Place an oil tank under the Carter		3	No	Yes	○	Minimize
11. Remove Carter Screw for draining		5	Si	Yes	○	Optimize
12. Put Carter's cap back		3	Si	Yes	○	Optimize
13. Remove oil filter		3	Si	Yes	○	Optimize
14. Place New Oil Filter		3	Si	Yes	○	Optimize
15. Remove Engine oil plug		2	Si	Yes	○	Duplicat, link to 11
16. Pour 4 liters of oil		5	Si	Yes	○	Optimize
17. Check oil level and add if necessary		3	Si	Yes	○	Optimize
18. Inspect for oil leaks and tighten if required		2	Si	Yes	○	Optimize
19. Remove used oil tank		3	No	Yes	○	Duplicat, link to 12

20. Lower ramp unit or hydraulic jack		3	No	Yes	•															Minimize
21. Remove gas pump fuse		4	No	Yes	•															Minimize
22. Turn on auto to relieve fuel pressure.		3	No	Yes	•															Minimize
23. Lift on ramp or with auto hydraulic jack		3	No	Yes	•															Minimize
24. Remove gas filter		5	Si	Yes	•															Optimize
25. Insert a new fuel filter.		4	Si	Yes	•															Optimize
26. Put back 161 asolina fuse		3	No	Yes	•															Minimize
27. Lower ramp or hydraulic jack unit		3	No	Yes	•															Optimize
28. Remove the air filter		4	Si	Yes	•															Optimize
29. Place New Air Filter		3	Si	Yes	•															Optimize
30. Disconnect wires from the spark plugs		5	Si	Yes	•															Optimize
31. Remove 4 Spark Plugs		5	Si	Yes	•															Optimize
32. Remove cylinder head cover		5	No	No	•															Eliminate
33. Calibrate Valves		6	No	No	•															Eliminate
34. Put on the cylinder head cover putting silicone on it		5	No	No	•															Eliminate
35. Inspect used spark plugs		4	No	No	•															Eliminate
36. Calibrate new spark plugs		4	No	No	•															Optimize
37. Put new spark plugs with the correct torque		7	Si	Yes	•															Optimize
38. Test right Ohms of spark plug wires		4	No	No	•															Eliminate
39. Place Spark Plug Cables		4	Si	Yes	•															Optimize
40. Inspect correct order of spark plug wires		4	No	No	•															Eliminate
41. Inspect fluid levels		5	Si	Yes	•															Optimize
42. Fill fluid level (brakes, direction, coolant, windshield)		5	Si	Yes	•															Optimize
43. Scan unit to detect any electronic failure		8	Si	No	•															Create need for sell to client
44. Turn on the unit and observe its performance		5	No	Yes	•															Minimize
45. Test vehicle on the road		8	No	Yes	•															Minimize
46. Washing, vacuuming and washing the vehicle engine		12	Si	Yes	•															Optimize
47. Inform the client of his finished service		3	No	Yes	•															Minimize
48. Move vehicle to delivery area		3	No	Yes	•															Minimize
49. Verify service with the client		11	No	Yes	•															Minimize
50. Bill and exit the vehicle		10	No	Yes	•															Minimize
Total		236 min				38	5	1	3	1	2									

We can observe from the previous diagram all the activities of the Tune up process that are carried out in the Company to be able to provide it. By analyzing the activities with the Rother and Shook criteria, we can evaluate them and determine if we should minimize, optimize or eliminate them like as indicated in red color. In the case of operations that have a red color in the action column, we can note 10, the first 3 are recommended to join a specific activity, the next 3 refer to calibrate the valves operations that are only carried out when the client indicates a **major tune up** including said activities plus cleaning of injectors, washing of body of acceleration, general revision of the unit, balatas, bands. Totally different from the case we are dealing with, which is a **preventive** tune up, which includes: oil change, changes of air filters, oil, gasoline and spark plugs. For the remaining 3, the inspection of the used spark plugs is not necessary since they will be replaced by new ones, the calibration of the new ones neither because they are already calibrated from the factory and to verify the Ohmeaje of the spark plug wires is of more than if had problems the unit would not have arrived on its own. And the last one refers to using the scanner to detect general faults for which is not necessary and that at the end of the service this can be offered to the client. The waste detected in the process analysis diagram is described below:

Waste identified in the previous Analysis Chart

- 1. Knowledge, Experience and creativity of employees.** The company SAINT LOUIS T does not have a system that takes advantage of the knowledge, experience and creativity of the employees, much less with a system of recognition towards them for their motivation. The problems that arise when providing the service are resolved by the Service Manager, for this reason if this is not found generates delays. The employee is not considered in this activity and the delegation of responsibility is something that must be taken into account.
- 2. Unnecessary movements.** The mechanical technicians, assistants and other personnel have to move severe meters in the facilities, to look for tool and spare parts for the execution of the operations.
- 3. Inventory.** There are 2 areas that store the spare parts, it does not have a safety inventory, that is, if a spare is missing, it must be ordered immediately and if the work is urgent, it must be purchased directly with the retailers. In this part only for the tuning service it has been suggested to handle a safety stock of filters, spark plugs and oil.
- 4. Overprocessing (Duplicate activities).** There are activities such as pick up of spare parts and tools, removal and assembly of spare parts, inspections and filling of fluid levels in the mechanical maintenance stage, where duplicated activities are identified that can be merged with one another to form one due to inadequate coordination, since there is no procedure that standardizes these activities.
- 5. Transport.** The movement of the unit is slow by units that occupy a place and have already been serviced, in addition to units that stay in “stand by “because the client has not given indications to continue with his service which generates slow fluidity and in part also to the disorder of the facilities.
- 6. Waiting Times.** This waste is detected in the reception stage when there are no necessary spare parts these have to be ordered or bought what they generate, in the mechanical maintenance stage at the time of capturing the available spare parts, there is no inventory of them so the technician or owner personally have to look for them. In the supply of tools a similar problem is noticed since there is no detailed control over these, that is to say that some of these tools could be being used by some technician or in any case these are disordered making their location difficult.

In the step 6 a standard work sequence is proposed to achieve a time of 140 mins by analyzing the operations performed in the DAP described above

Takt Time

We will analyze the service by calculating the Current Takt Time, which refers to the production rate that must be followed according to the time available based on a certain demand. The formula is $Takt\ Time = \frac{Available\ Time}{Demand}$.

The Takt Time formula is $TT = \frac{Available\ Time}{Demand}$, to make the calculation consider the following premises:

- ✓ There are 46 available work hours weekly, which annually represent 2208 hours that are equivalent to 132,480 minutes.

- ✓ Monthly there is an average demand of 50 units for mechanic service, which annually represent 600 units. Providing a Tune Up service to a Type Sedan unit represents a sale of \$ 1500 and a gain of 26.66% on the sale.
- ✓ Now for the Takt Time Current the formula is applied as such, but for the calculation of the Future or desired Takt Time it is contemplated to lower the Lead Time to 140 minutes which is the time handled by Toyota, Bosch Service and the labor guide for real time pro, for this it was necessary to clear the demand of the original formula to obtain the number of services that we can perform with a Lead Time of 140 minutes, where $D = \text{Time Available} / \text{Takt time}$

Now for the purposes of analysis and calculation, suppose that the number of services refers to Tune Up to particular customers since there are a variety of mechanical services. The approach we want to show is that if the model methodology is applied to the key services of each client, it will be possible to reduce the Lead Time considerably and, as a consequence, productivity will be improved and cost reduction will become eminent. Consider the following information (MXN):

Table 9. Takt Time

CONCEPT	TT	Annual Available Time	Annual Demand	Annual sales	Annual Income
TT Current	221min.	132,480 mins.	600 units	\$900,000	\$240,000
TT Future	140 mins.	132,480 mins.	946 units	\$1,419,000	\$378,000
	-81mins = 40.6 %		+346 units = 57,6%	+ \$519,000 = 57.6%	+ \$138,000= 57.6%

The Actual Lead Time of the Up Service is 236 minutes versus 221 minutes of Takt time. This TT indicates in theory that every 221 minutes 1 tuning service is performed but in practice it takes 236 minutes to do it.

By identifying the waste and applying the Lean tools, it is projected to achieve a gradual reduction of 40% of the Total Lead Time from 236 minutes to 140. By reducing the service to 140 minutes with the same annual available time, 346 units could be served. Which represents an increase of 57.6% in demand.

The challenge is to achieve this and to be able to do so it is necessary to identify waste by mapping all the activities or operations that are carried out in the process. It has to be gradual starting with small goals from 5% up to 40%.

The Future TT would mean increasing sales by 57.6% which translates into an increase in profits of \$ 138,000 per year. Take into account that the profit margin of the Tune Up service to Private customers is the lowest compared to the other clients' key services:

Imagine the potential that would be had to start standardizing the key services of each client to postpone doing it with all the services offered by the SME. There would be a reduction in Lead Time, which would lead us to increase profits, improve productivity and deliver on time units which would guarantee Saint Louis T. satisfied customers.

6. PROPOSE LEAN TOOLS FOR IMPROVEMENT THE SERVICE

The future VSM of the process shows the reduction from 236 minutes to 140 minutes of Lead Time, indicating the time per stage s and also indicates the Lean tools proposed to reduce the Lead Time of the process (Figure 5. Future VSM):

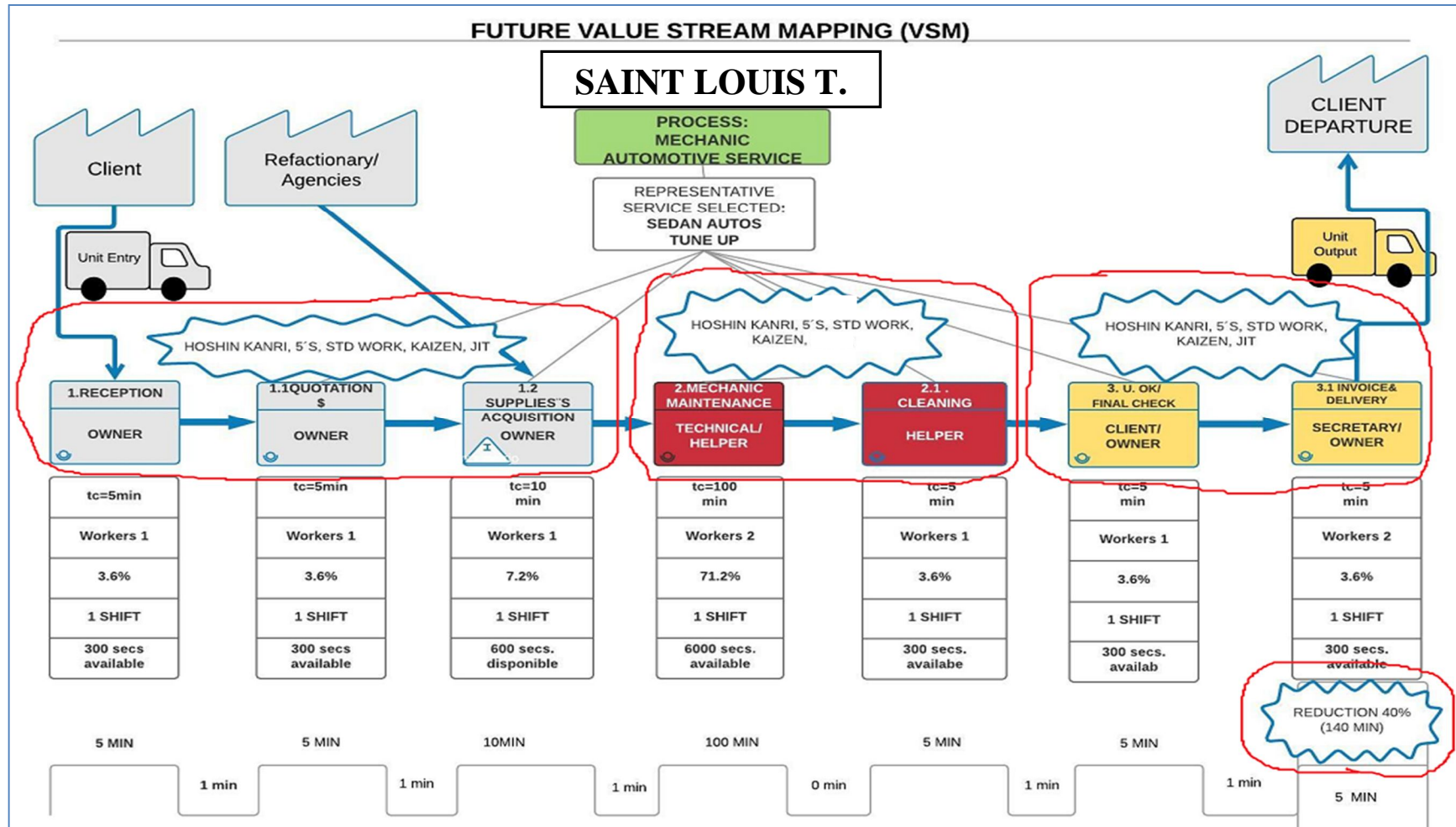


Figure 6. Future VSM

We can see tha the Lean Tools to apply for optimize the value chain in order of importance of the root causes that delay the service according to the obtained in the Pareto diagram, Ishikawa and Future VSM, we have:

1. Informal Mechanical Procedures (26.5 %)

Lean Tool proposed: Standard Work, at the beginning, standardize the tune up service for private customers of sedans and gradually standardize them in their entirety.

Date:		Pag. 1 de 1		
Revised:		Versión: 01		
PROCESS: TUNE UP MOTOR AUTOS SEDAN				
STAGES	STD WORK	TIME (objective)	%	
1. RECEPTION	1. Receive unit and record requirements	2	1.43%	
	2. Quotation and filling in the entry form	5	3.57%	
	3. List of spare parts available and missing	2	1.43%	
	4. Purchase of spare parts	10	7.14%	
	5. Move unit to mechanical maintenance area	1	0.71%	
Cycle Time		20 min	14.29%	
2. MECHANIC MAINTENANCE	6. Capture Tools to give service	5	3.57%	
	7. Capture spare parts available from inventory	5	3.57%	
	8. Lift unit on ramp or hydraulic jack	4	2.86%	
	9. Place a tank for used oil under the Carter	1	0.71%	
	10. Remove Engine oil plug and Carter screw	4	2.86%	
	11. Remove used oil and screw Carter plug	3	2.14%	
	12. Remove oil filter	4	2.86%	
	13. Place New Oil Filter	4	2.86%	
	14. Pour 4 liters of oil	5	3.57%	
	15. Inspect for oil leaks and tighten if required	3	2.14%	
	16. Descend unit	1	0.71%	
	17. Inspect oil level, add if necessary and put engine oil plug	2	1.43%	
	18. Remove gas pump fuse	2	1.43%	
	19. Turn on car to relieve gas pressure	2	1.43%	
	20. Turn off and lift unit	1	0.71%	
	21. Remove gas filter	4	2.86%	
	22. Place New Fuel Filter	4	2.86%	
	23. Descend unit	1	0.71%	
	24. Put back gasoline fuse	1	0.71%	
	25. Remove the air filter	2	1.43%	
	26. Place New Air Filter	2	1.43%	
	27. Disconnect spark plug wires	2	1.43%	
	28. Remove 4 Spark Plugs	5	3.57%	
	29. Calibrate new spark plugs	2	1.43%	
	30. Put 4 spark plugs	5	3.57%	
	31. Place spark plug wires	2	1.43%	
	32. Inspect and fill fluid levels if necessary	4	2.86%	
	33. Turn on the unit and observe its performance	6	4.29%	
	34. Inspect gas leak, tighten filter if required	2	1.43%	
	35. Test vehicle on the road	10	7.14%	
	36. Washing and vacuuming	5	3.57%	
	37. Move vehicle to delivery area	1	0.71%	
	38. Inform the client of his finished service	1	0.71%	
	Cycle Time		105min	75%
	3. DELIVERY	39. Verify service with the client	5	
		40. Bill and exit the vehicle	5	
	Tiempo de Ciclo		10 min	7.14%
	Total	TOTAL CYCLE TIME (Lead Time)	140min	100%

Elabored by: Noe Aguila

Revised by: Pedro T.T

Authorized by: Amaday T.G

2. Dead Times by disorder. (24.2 %)

Lean Tool proposed: 5'S Starting with Pilot Area: Mechanic Maintenance and gradually to all areas of the work shop.

3. Lack of Planning (20.5 %)

Lean Tool proposed: Hoshin Kanri for Strategic Planning, deployment program to support the owner in the planning of SME activities.

- Lean tool proposed KAIZEN: Encourage the participation of employees in improvements in any area of the process by using a suggestion system through a suggestion box ()
- Continuous training in Lean Manufacturing Philosophy to all staff
- Actions to motivate staff such diplomas or worker of the month
- Work under the Just in Time system regarding the acquisition of spare parts, supplies and implement a safety stock in spare parts that are in high demand to favor service time

7. ACTIONS TO KEEP THE LEVEL ACHIEVED

The following actions are proposed to maintain performance and guarantee the achievement of objectives:

- Establishment of Indicators and Controls in the Process
- Publicize the results
- Delegate activities
- Ensure continuous support from the Owner
- Problem response plan
- Development of process manual
- Standardize all services in full.
- Statistical process control
- Standard work

8. RESTART CONTINUOUS IMPROVEMENT CYCLE THROUGH THE SELECTION OF A NEW SERVICE TO IMPROVE IT

When you finish applying the methodology of continuous improvement proposed the next step is to select a new service to improve it in the case of the company in question, the other service that gives good returns and also presents a delay in the Lead Time is the motor adjustment patrols of public customers or you can select a service that the owner requires and that improving it impacts the profitability of the company.

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To my Children:

Alexander, Christofer and Brandon, for being the reason of my existence.

To my Wife Sandy: For all your support in good and bad times

To my Mom: I will never stop thanking my Mother for giving me everything I always need.

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Manuel: For always supporting me in all aspects and for being an example of an older brother

Leo: for supporting me selflessly in my development in Des Moines Iowa.

Mary: For being my initial guide in my professional development.

CONCLUSIONS

The application of the proposed Continuous Improvement Methodology to optimize the value chain the mechanical service process allowed us to identify the main opportunity areas of the Sme, as they are:

Informal mechanics procedures: what led us to suggest the Lean tool: Standard Work tool. Start with the key processes of each client and gradually standardize in full the services.

Dead times by disorder: Implement 5's starting with a Pilot area, which is suggested to be the area of mechanical maintenance and and little by little to all areas.

Lack of planning: Hoshin Kanri is suggested for strategic planning as a Lean tool to help the Owner in the activities that he develops in his Company, for which a deployment program will be developed as a guide and support of the same.

In Tracing the Current VSM we realize that Lead time is through the clouds precisely at 68.5% up compared to Nissan, Toyota, Bosch and Labor Guide that are in 140 minutes. This comparison indicates that the Pyme Saint Louis T has to improve its service times, beginning with the basis of any improvement project such as the 5'S, then continue with the standardization of all its mechanical services and as a good start to start with the key services of each client. The future VSM shows us 140 minutes of Lead Time which is the challenge to achieve, set small short-term goals maybe 2.5% weekly until you reach the desired goal. We have to analyze all the o activities of the process through analysis diagrams to find the repetitive activities and the ones that cause waste to be able to optimize the value chain of the process and leave those that add value.

The Owner represents one of the crucial parts of the improvement project because it is required to be aware of the change since the success or failure will depend on their level of commitment. The change and

adoption of a Lean work culture through constant staff training and being open to change in improvement projects is a commitment that all staff must assume and be responsible for.

The most important element in the process that we must not forget and take into account for the improvement of it is to use the capacity, creativity and talent of the staff. It is common for improvement projects to forget this element when Taichi Ohno himself commented that instead of the Toyota Production System he would have preferred to call it the Thinking Production System since the success of the system depends on the personnel.

The realization of this research leads me to the following reflection. The most relevant thing that this research demonstrates is that the techniques.

Through the analysis and situational diagnosis of the company, it was possible to detect serious flaws in the service processes directly influencing customer satisfaction and the profitability of the company, such as the following:

- The information provided by the Ishikawa diagram in the "Methods" block indicates that the organization has the elements of work work, which refers to the standardization of the different work processes.
- The information provided in the exchange of ideas in relation to the waste detected also indicates that the company does not have a "Suggestion System" that takes into account, recognizes and rewards the improvement ideas provided by the staff.

REFERENCES

Hernández Matías Juan C. “Lean Manufacturing: Conceptos, técnicas e implantación”. Escuela de Organización Industrial. Primera Edición. España. 2013.

Rother & Shook (2003), Learning to see, alue Stream Mapping to Add Value and Eliminate MUDA, USA, Lean Enterprise Institute.

Womack, James P., Jones D. T, (1992). Lean Thinking, U.S.A, Ed. Mc Graw Hill

Womack, J. & Jones D.T, (1996). The machine that changes the world, U.S.A, Ed. Mc Graw Hill

Villaseñor Alberto, (2007), Manual de Lean Manufacturing Guía Básica. México. Limusa.