Increase of fuel efficiency in a passenger road transportation company

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Abstract

In Mexico, fuel consumption costs are almost a half of the total operational costs in passenger road transportation companies so that even small improvements in this matter can positively affect their profit. This work presents the results of applying a continuous improvement project in the fuel efficiency department for one of the main bus fleets of an important transportation company in the region. We describe the application of the PDCA methodology. During the "Plan" step, we also rely on relevant literature to justify the strategies proposed. Among these strategies are: a new measurement & control system of fuel efficiency, the improvement of the value stream in the maintenance department, a system to increase the fuel energy efficiency using additives, and a new incentive program for drivers. Results on the implemented strategies and estimations for the ones still on progress show that the company will be able to increase up to 3.8% the fuel efficiency of the fleet under study.

Keywords

Fuel efficiency, bus fleet, rewards, measurement system, PDCA

1 Introduction and Background

The total world delivered energy consumption due to the passenger transportation activity was nearly 15% in 2012 (i.e. 60% of the whole transportation sector) (EIA, 2016). In the Transport Forum for Latin American, the improvement of buses and the passenger transportation service was among the most common actions declared for a Sustainable Low Carbon Transport (FTS, 2011). In Mexico, where transit transportation moves 98% of domestic passengers, fuel consumption represented about 50% of the companies' variable costs (Huertas et al, 2017).

Among the many worldwide approaches to decrease fuel consumption, and hence, pollutant emissions on current vehicles fleets are: eco-driving techniques (e.g. Díaz et al, 2017, as one of the few reported Latin American experiences out of 218 references in Journals indexed in Scopus), powertrain reconfigurations (e.g. Huertas et al, 2018), green routing problems (e.g. Demir et al. 2014), change or conversion to cleaner vehicles (e.g. the CiViTAS Initiative for cleaner and better transport cities in Dyn@mo cities of the European Union (CiViTAS, 2017);

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improving the energy efficiency of fuels (e.g. 90 references only in the Fuel Journal), and the less documented strategies, the continuous improvement projects around fuel consumption reductions, as the one that we present here; which could be seen as a specific Lean-Green model for transportation industry (e.g. Abreu et al, 2017).

Continuous improvement (CI) project utilizes dedicated project team to improve a process or system typically with minimal capital investment and over a relatively short period of time to improve organizational performance (González Aleu and Van Aken, 2016). When it comes to improvements achieved through reducing the consumption of resources, it is inevitable to deal with Lean philosophy and its tools. The main focus of Lean is the elimination or reduction of all non-value added activities (NVA) or wastes. In general, a NVA is any activity for which the customer is not willing to pay. There are seven types of waste: overproduction, over processing, transportation, defects, motion, inventory, and waiting (Originally in Ohno, 1986 (Abreu et al, 2017), Belhadi et al (2017)). We call a Lean-Green project as a CI project that pursues improvements in performance indications of at least two of the three pillars of sustainability: economic, environmental, and social; through the elimination or reduction of waste. This project presents the development of a Lean-Green project with the goal of improvement a main performance indicator: Fuel efficiency. By doing this, improvements are achieve on: (a) economic: reduction of wastes (i.e. over processing) and a decreased fuel consumption, (b) environmental: as a consequence of (a), less pollutant emissions, and (c) social: a better performance assessment for drivers.

1.1 The firm

This project is developed for the federal services division of one of the main providers of passenger road transportation services in Mexico. It has been in operation for more than 83 years with around 7,600 employees. They offer mainly four different transportation services: Federal, Industrial, Parcel and Express under 5 different brand names. For federal services, it offers an average of 2,000 regular daily departures and a fleet of more than 700 units. The service is also divided in four segments: Executive, premier, regular, and suburban. Figure 1 shows the fleet composition by brand and segment. The Company has 7 maintenance workshops in different cities for the federal fleet. Each one serves between one and five divisions. A division is understood as a group of roles (set of origin - destination routes).

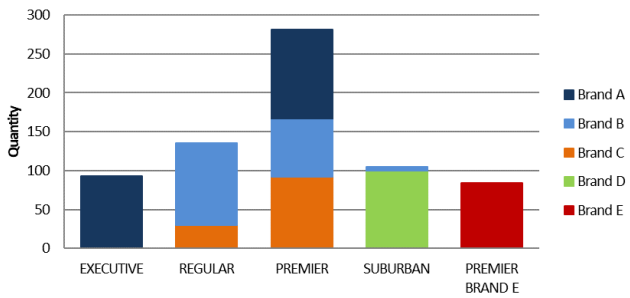


Figure 1. Fleet composition by brand and segment

One of the key performance indicators at an operational level is the fuel efficiency (FE) of the fleet, measured in [km/lt]. During the last years, the achieved FE has not reached the goals imposed by the company's direction.

2 Methodology

The methodology of CI used in this project is PDCA. This is the fundamental improvement cycle of the Total Quality Management methodology. It was chosen considering the management conditions of the company and recognizing that the goals of the company seek continuous improvement rather than the operational excellence (as DMAIC in Six Sigma or Shingo Philosophy do), making everyone in the organization participants in the results and responsible for the reduction of errors (Gershon 2010). PDCA is a cycling four stage model (Plan, Do, Check, and Act) used to achieve continuous improvement in business process management. It was firstly proposed by Shewhart (1951) and widespread and adjusted by Deming afterwards as PDSA, by changing the "C" for "S" standing for "Study" (Moen, 2009). Figure 2 shows the PDCA model adapted to this project. We describe below the phases with focus on the Plan phase.

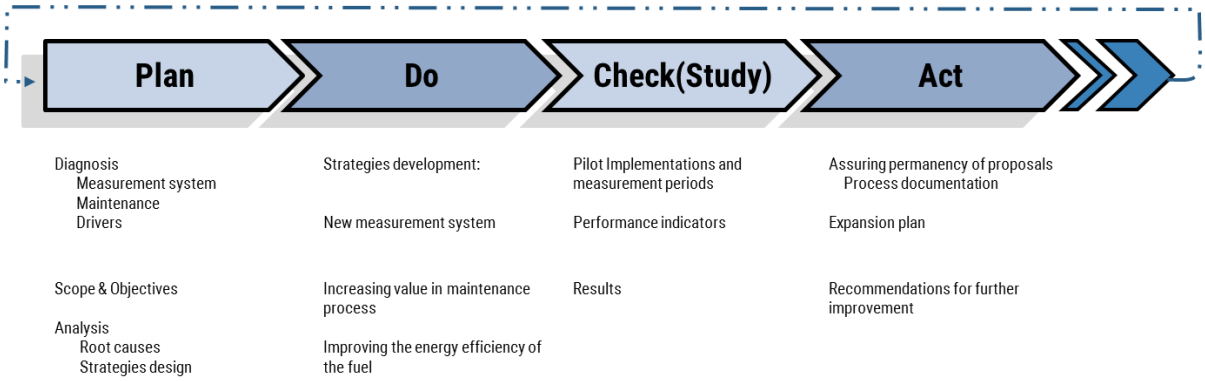


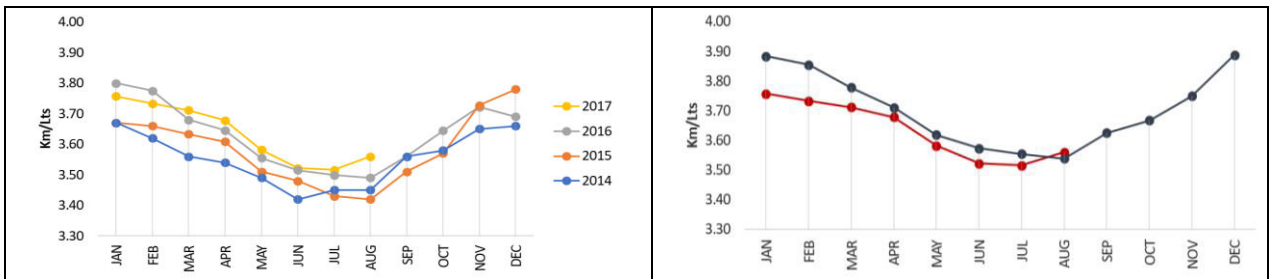
Figure 2. PDCA methodology

3 Plan

In this stage, the scope of the project was defined and based on a previous examination of the symptoms and their causes the objectives. At the end, strategies were elaborated to counteract the problem's causes found. The client is defined as the Senior Federal Transportation Management in the Fuel Control department. The main indicator is the Fuel efficiency (FE), measured as the ratio of the total kilometers traveled with the liters of fuel registered. Monthly goals are declared at the end of every year for the next one.

3.1 Problem statement

As can be seen in Figure 3(b), FE does not meet the goal. Figure 3 also shows the seasonality behavior of the FE. It is affected by the use of air conditioning inside the buses due to the high temperatures in summer season. An average annual increase of ~0.03 km/l can also be observed. In 2016, the year ended with a difference of 0.06 km/l between the goal and the achieved performance, while until July 2017 the average difference was 0.07 km/l below.



(a) Fuel efficiency of the last years (km/l) (b) Fuel efficiency (km/l) in 2017 versus the goal.

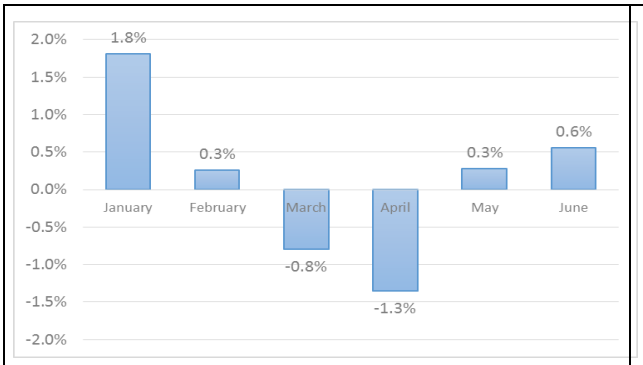
Figure 3. Fuel efficiency vs the goals

3.2 Objectives and Scope

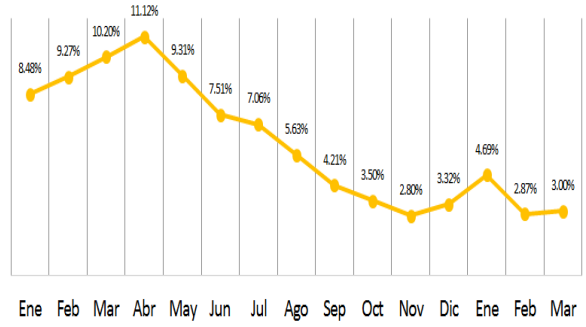
The scope of this project is limited to the units belonging to the federal fleet; that is, around 700 units and the processes over which the Department of Fuel Control has control on. The general objective was set to increase the average FE of the company's federal fleet by at least 2.2%, in order to achieve the stablished goals. In addition, four specific objectives were defined that would help achieve the general objective. These particular objectives are: (a) Increase the flow of units serviced in peripheral maintenance by at least 20%, (b) Establish a measurement system that includes parameters, indicators and analysis of unit performance, (c) Increase performance due to lack of power in the engine by an average of 3% per unit, and (d) Define an effective strategy for tire calibration.

3.3 The Measurement System

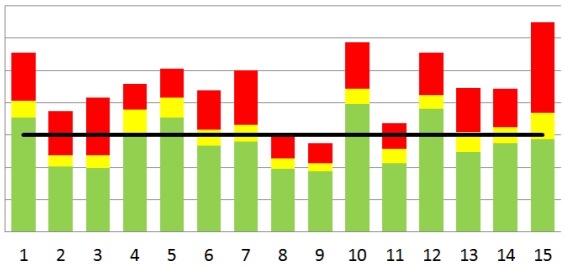
As mentioned before, the company follows up on a monthly goal indicator. Individually, a monthly FE goal is assigned to each unit. This goal is calculated with a specific formula in which the unit's previous monthly goal is taken and affected by a seasonality factor that increases or reduces the goal according to the performance of the same previous year's month and the previous month.



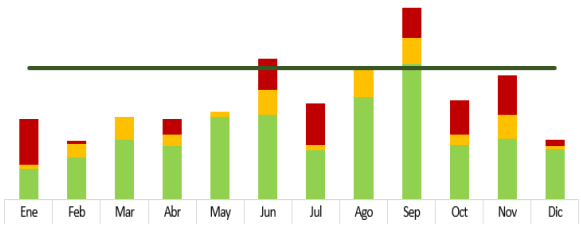
(a) Relative differences between the declared goals and the obtained ones if the individual goals were met.



(b) Fuel efficiency increase of the units after peripheral maintenance.



(c) Peripheral maintenance process value in minutes, per sample. Green is AV, Yellow is NVA, Red is Waste. Black line is the standard.



(d) 2017 Scheduled Peripheral maintenance. Green: certified units. Yellow: unpostponable units. Red: unattended units. Black line: Capacity.

Figure 4. Summary of diagnosis

Not being the same formula to compute the goals, we performed a verification exercise of this formula, in which we proved it didn´t match. The achievement of the individual goals led to different general goals. Figure 4(a) shows these differences in the first semester of the year, showing an average absolute difference of 0.03 km/l.

3.4 Maintenance Operations

Following Litwin (2017), a Value Stream Map was carried out to represent the unit care process, throughout the different phases of the integral maintenance process. In addition, you can see their corresponding cycle times, transfer times, "takt time" and percentage of use. The Value Stream Map is a tool used to perform analysis of manufacturing or process systems. Its main objective is to represent the flow of materials (and information) within the value chain, specifying the relevant criteria for the total understanding of the process (Stadnicka, 2017). After this exercise, the current "Lead Time" was estimated in 13.8 hours.

One of the operations that impacts directly in the FE is the peripheral maintenance. This is the name given to the maintenance operations different from the predictive and corrective maintenance programs. Buses that are cataloged as “certified” and those that are recommended to “unpostponable” maintenance for having low FE pass through this process. Figure 4(b) shows the short-term impact on FE of the units that pass for this process. The potential of improvement goes up to 11%. The Peripheral maintenance unit serves a monthly average of 79 units while the declared capacity is 120 units per month. This gives a focus of potential improvement.

The current maintenance process was studied and the most relevant activities were identified according to operational purposes. These activities were categorized in those that add value (AV), those that do not add value, but are necessary (NAV) and those that do not add value at all (Waste) as in Figure 4(c). With this, a Value Stream Map was developed, and the maintenance cycle time was estimated in 7.6 hours. We could also observe that 26% of activities were repeated within the three processes (pits, specialist, and maintenance).

3.5 Fleet Performance

Each month the units are classified according its previous performance (i.e. fuel efficiency) and the corresponding monthly goal in four categories: (a) comply: those units that are above the goal. The next three levels do not comply the goal and are determined by quartile thresholds. (b) Normal: units that are below the goal but in the first quartile, (c) Low: units that are below the goal but in the second and third quartile, and (d) Unpostponable: units in the fourth quartile. After a review of the performance during the last 15 months, on average, 44% of the units did not comply the goal. It worth nothing that this categorization highly depends on the individual measurement system of the unit. So, a poorly assessment of a unit can lead to a mistaken categorization, causing incorrect units being sent to maintenance, for example.

3.6 Drivers

Drivers play an important role in this process, since their behavior is one of the factors with the greatest impact on the performance of the units. When an operator enters the company, he goes directly to the company's driving school, where he takes a 70% practical and 30% theoretical course for six weeks. This course ends with a theoretical examination and a practical evaluation, which when approved, the operator is ready to move on to the next phase; certification in route and type of platform.

Once certified and with the approved exam, they start working at the base segment and they are subject to random tests by a FE specialist. According to their performance, they can change the segments where they drive. The specialists also record "faults" in the driving techniques that can be sanctioned or taken into account negatively by the awards program. On the other hand, drivers that comply with the techniques and the FE goal, can be creditors to an incentive. On average, 49.6% of all active operators meet this criterion. During the last 12 quarters, an average of 327 drivers were awarded, representing 50.31% of the operators that met the criteria for the award, and the 24.9% of the total drivers.

Due to the current system of award scaling, cases where drivers receive higher remunerations than fuel savings have been recorded. The main cause of this anomaly is that the model used does not make comparisons between savings and incentives, resulting disproportional in certain occasions. Currently, an average of 29 operators receive quarterly awards almost three times their savings, while operators with better results receive minor awards for not being in the same position of the staggering of products.

3.7 Root Causes Analysis

The objective of this step is to identify the root causes of the problem by understanding how and why the problem is generated, seeking to reach the deepest causes and confirming these through valid data (Pulido, 2010). One of the most useful tools for this stage is the diagram of Ishikawa or better known by cause-effect diagram, which lies in the graphic representation of existing causes within a problem. This model shows the relationship between a problem and its possible underlying causes. And, it is mainly oriented to obtain improvements of systems related to quality (Simanová, 2015). We used this tool. As a result, we identified 78 symptoms as potential causes of the problem. Of these, the following five root causes were identified:

1. Repetition of activities in the peripheral maintenance; specifically, in the review of the pit area, the specialist evaluation and in the workshop.
2. Rewards driver program does not incentive fuel efficiency
3. Faults in the performance measurement system for budget and poorly established performance
4. The fleet age: 66% of the units are more than 10 years old.
5. No control process in tire management.

3.8 Strategies Design

In order to design the solution strategies, we performed a literature review on solutions associated to the root causes found. We took care on the efficacy and implementation times of those solutions. The search was performed on the ScienceDirect database with focus on the most recent publications. Table 2 summarizes the findings.

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Table 2. Solutions strategies found in literature

Area	Strategy	Reference	Improvement in FE (%)	Implementation time (months)
Fuel	Hybrid electric-hydrogen	(De Miranda, 2016)	46.6%	8
	Hydrogen	(Christopher, 2007)	10%	16
	Compressed natural gas (CNG)	(Burnham & Laughling, 2009)	6 -11%	60
	Additives	(Soukht et al, 2015)	3%	4 -5
	Biodiesel	(Imadadul et al, 2016)	1 – 6%	12
Mechanical changes	SOFC APU	(Rechberger, 2016)	28 – 30%	12
	Heat recovery systems	(Deccord, 2017)	54%	24
	Tire calibration	(Leduc, 2009)	2 – 3%	6
		(TireRack, 2017)	1 – 4%	4
	Additional gear	(Maloney, 2017)	5-6%	Simulation
		(Ahangar, 2010)	5%	8
Maintenance	Automatic Vehicle Location	(Mayer, 2011)	20%	36
	Periodic revisions	(Crisan & Nicolae, 2013)	5%	6
Efficient Driving	In-Vehicle Data Recorder	(Toledo & Shiftan, 2015)	3 – 10%	12
		(Tulusan & Elgar, 2012)	3%	5
		(Stillwater & Kurani, 2014)	2%	6
	Eco-driving	(Díaz et al, 2017)	5 – 6%	6
		(Barla, 2015)	3 – 4%	4
		(Ayyildis et al, 2016)	3%	10
		(af Wahlberg, 2015)	2%	12
	Monetary incentives	(Lai, 2015)	7%	6
		(LaMere, 1996)	6.2%	6
		(Schall & Mohnen, 2015)	4%	6
		(Schall, 2015)	3.5%	6
Logistics	Route optimization	(Eliiyia et al, 2012)	8.1%	120
		(Jianghua et al, 2015)	5%	Algorithm

Based on these findings, we conduct a selection process of the strategies to work on. The strategies were selected according to a priorization based on: the scope of the intervention, their expected impact, the total investment of the strategy, the implementation time, and an additional feasibility criterion discussed with the client.

Table 3. Solution Strategies

Root Cause	Strategy selected
Repetition of activities in the peripheral maintenance.	Adding value to the maintenance process.
Rewards driver program does not incentive fuel efficiency	Develop a reward system that promotes the increase in fuel efficiency.
Faults in the performance measurement system	Restore the measurement process so that, when meeting the objectives per unit, the monthly goal is achieved.
The fleet age	Implementation of additives that help generate more power in the engine.
No control process in tire management.	Implementation of an electronic device to ensure the calibration and rolling of tires.

4 "Do" phase

To describe this phase, we summarized the implementation actions in Table 4. For each strategy, a description of the specific action (e.g. pilot, documentation, experimentation, etc.), and the type of effect on fuel efficiency is given.

Table 4. Strategies Implementation

Strategy	Effect on FE	Actions
Value to maintenance	Direct	Process redesign, Analytical simulation
Reward system	Indirect	Redefinition, Financial evaluation
Measurement system	Indirect	Redefinition, Pilot implementation
Additives	Direct	Experimentation, Analysis, Selection, Process definition
Tire calibration	Direct	Financial evaluation, Selection, Process definition

Experimentation and pilot implementations were carried out between August and December, 2017. Actions related to process definition or redesign were documented, and passed through the internal approval process.

5 "Check" phase

Check means to revise the effects of the implementations. Also called "assess" or as Deming adjusted the "study" phase (Moen, 2009), this phase also includes the study of the results to learn of the improvement experience and to predict onward results. In this section, we describe with more detail the strategies mentioned in the previous phase and present some results.

5.1 A New measurement system

An additional literature review was carried out to identify the variables to be considered in an estimation model of fuel consumption or fuel efficiency. In Table 5, we included researches on fuel consumption estimation models and the variables they used in their models. Cycles means if the path the vehicles road or its conditions are used in the model; that is, the route to which it was assigned in a period of time (Weng, 2017). Seven variables were evaluated: brand name, segment, division, role (or route), year, axles, and engine type. For each variable either a correlation analysis or a simple linear regression was performed, with FE as the response variable. The residuals of these tests were not distributed normally, which meant that a single variable was not capable of explaining the performance alone. We also analyzed the correlations among the explaining variables and performed additional multiple regression models to estimate FE.

We performed statistical analysis as outlier tests, normality tests on residuals of regression models, and analysis of variance (ANOVA). As a result, we found an interesting model that explains FE with only three variables: Axles, year and role (or route) with an adjusted $R^2 = 91.2\%$. Table 6 summarizes the statistical results, where R^2_{adj} close to 1 reflects a high-quality estimation of the model, low P_values reflect the model's and the variables' significance (i.e. P_values below α=0.05 indicates the variables are statistically significant.), and a P_value above α in the Anderson-Darling (AD) test for normality of residuals confirms the normality assumption of these values.

Table 5. Variables considered in fuel estimation models

Criteria / Reference	Route	Year	Brand	Power (HP*)	Motor size	Vehicle mass	Driver data	Cycle
Wang, J. (2017)		X	X	X	X	X		
Wang, J. (2015)		X	X	X		X		
De Abreu, J. (2015)	X					X	X	
Alcántrar (2015)	X	X						
Amer (2014)	X				X	X		X
Weng (2017)								X
Turkensteen (2017)	X					X		X
Lee (2014)								X
Ivkovic (2017)	X		X					X
Hung (2015)	X							X
Delgado (2011)	X							X

*Horse power

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With these results, a new measurement system was proposed in which the individual goals are estimated for each group with common Axle-Year-Role combination, in such a way that they impact directly (and correctly) in the general fleet FE goals. The resulting model was delivered to the company on an Excel sheet as a kind of simulator, which will allow them to determine dynamically the expected performance for each group.

Table 6. Summary of a multiple linear regression model to estimate fuel efficiency

Sample size	Regression P-Value	Regression R^2_{adj}	Axle P-Value	Year P-Value	Role P-Value	AD Normality test for residuals P_value
677	0.000	91.18%	0.000	0.098	0.000	0.122

5.2 Incentive program

The new incentive program will be monetary and not in kind (Figure 5). LaMere (1996) reports efficiency improvements due to this kind of incentives up to 6%. In addition, this decision eliminates the costs associated to the purchasing, storage, and management of the prizes in kind. Among the changes in the new incentive program are: (a) more frequent and immediate. This is, the frequency will be monthly or at most every two months; (b) Based on the driver's behavior, not only while driving but in general. This is, to be a candidate to get a monetary incentive, the driver shall pass a checklist with the following aspects: continuous logging in the system, reports delivered on time, the driving test by supervisors must be passed, no complaints recorded, etc. (c) Fuel efficiency achieved is compared to the individual goal. The driver shall overpass the goal plus a given threshold; (d) the additional efficiency is translated to monetary savings, (e) a given (superior) percentile is subject to be prize; and finally, (f) a (fixed, predefined, and public) fraction of the monetary saving is awarded to the driver, and directly included in the payroll payment.

Figure 5. Incentive program scheme.

The proposal was delivered to the company, supported on an Excel sheet with a simulation of the effects of applying the specific rules and policies and compared to the last period of prizes with the previous scheme. The total budget was respected, and the proportion of drivers subject to prize and the amount of the prizes were estimated and compared.

5.3 Additives

A viable solution to counteract the fleet age effects on FE, according to the review of is the incorporation of additives to the fuel. The additives modify the diesel chemically, weakening the energy of the atoms and lengthening the life of the engines, delaying their wear. The fuel tends to give a better efficiency and emits considerably smaller amounts of nitrogen oxides (Subbarao, 2013). An additive is a chemical component that is mixed with diesel to maximize power with less fuel. It facilitates the release of energy between hydrogen and carbon and increases the calorific power of diesel to generate more power, which is directly related to performance (Subbarao, 2013). The release of energy facilitates combustion and allows greater pressure at a lower angle, that is, more quickly throughout (Ashrafi, 2015).

The results of implementing additives are indicative of a significant alteration in engine power, oil temperature and the proportion of pollutants released. The presence of metallic nanoparticles inside the combustion chamber increases the heat transfer to the fuel and shortens the ignition delay through an acceleration of the combustion

process. Meanwhile, these particles can help the fuel particles to penetrate more into the compressed air during the spraying stage. Having all these characteristics will improve the combustion and, therefore, reduce unburned carbons and other pollutants by reducing fuel consumption up to 3% accompanied by a 6% improvement in engine power (Ashrafi, 2015).

Five additive suppliers were considered in the study. We performed designed experiments to test the effect of the additives in FE. When it was possible, a sample of identical units with the same operation (e.g. route) was used as a control group. The analysis considered the effects after the decarburization period. Results were compared against the performance they had in the same period of the previous year, against the performance of the unit in the period prior to implementation, in the same year, and against the performance of the twin units (control group). Based on estimations of some inventory decisions (e.g. safety stock levels, reorder points, order quantities and frequencies), and the fuel savings recorded, a financial analysis was performed with NPV and recuperation periods as the main indicators, to suggest the additive to use. During the pilot test, 35 units (i.e. 5% of the total federal fleet) used added fuel and were controlled. They registered an average increase of 5.3% per unit.

5.4 Maintenance

There are three phases in the peripheral maintenance with 120 activities, divided as follows: pits: 44 activities, • Specialist: 28 activities, and Maintenance workshop: 48 activities. A reassignment and balancing was carried out, considering the greater capacity of action within each phase (pits, specialist and workshop). This, with the purpose of eliminating the repetition of activities and reducing the operation times of the integral process, increasing the flow of units attended monthly (Figure 13). After carrying out the relocation for the respective phases, the tasks to be performed decrease to 85 activities distributed as follows: pits: 37 activities, Specialist: 15 activities, and Maintenance workshop: 33 activities. In addition, a new Value Stream Map was developed as shown in Figure 6. The effect in the decrease of Lead time can be observed in 3.7 hours to 10.1hours, representing 27% of the operation, and making possible, the increase of flow of units throughout the maintenance stations.

To give support to these findings, a simulation of the proposed improvements was carried out in the ProModel 2014 software. The baseline simulation included the trip closure, pits, specialist, maintenance, review and release steps, and was fed with their respective cycle times, transfers, waiting, arrival and distribution of input data of the process. The results showed a projection of 85 units served monthly, which agrees with the current records of the company. Later, when changes were included, 128 units per month were served.

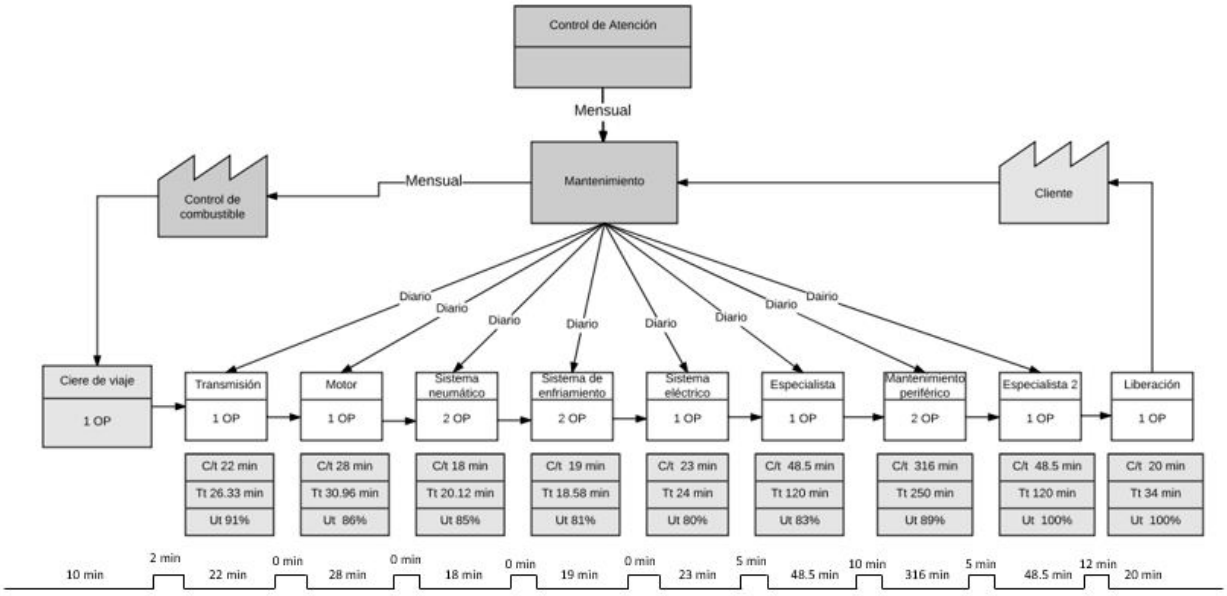

Figure 6. Value Stream Map of the proposed Peripheral Maintenance process.

When defining the findings of repetition of activities, a comprehensive checklist was developed in an electronic platform so that operators could access with the same user or employee ID and produce a shared report per unit. In addition, it will allow mechanics to write their observations inside the software and to send information to those in charge of any type of concern and anomaly within the process in question.

5.5 Tire management

One of the most interesting findings in the research was that ensuring the calibration and rolling of tires can reduce the consumption of energy by 2 to 3%, achieving as a consequence, increasing performance (Leduc, 2009). The pressure of the tires has a considerable effect on the rolling resistance. For truck tires, good calibration results in a 5-8% increase in rolling resistance and a 2-3% increase in power consumption. Maintaining sufficient tire pressure provides significant means for energy savings (Leduc, 2009). As a practical tool, the control of inflation pressure in the tires of heavy vehicles provides important means of suppressing the rolling resistance. Several monitoring systems are already available, and adoption has been encouraged (Choi, 2003) (Matter, 2014).

Currently, 45% of the fleet is not measured, so it is not possible to monitor and control the tires of these units. In addition, there are no maintenance alerts or control of assembly and disassembly of tires. The strategy proposed in this matter consists on the installation of two electronic meters with to streamline processes and increase the tire performance of the units through a procedural and support structure, ensuring the calibration and rolling of the tires. The strategy included: (a) identification of data recording needs, (b) supplier evaluation and selection, (c) redesign and documentation of functions to include periodical tire calibration and control, (d) automatic communication to send alerts to maintenance division, and (e) automatic alert to purchasing department. Financial projections considered a 10 year horizon, a 7% increase in the tire lifetime, and organizational changes.

6 Act

As part of the strategy's construction and implementation, protocols and documentation to facilitate an extended implementation were developed, such as: (a) a protocol to implement additives in the fueling stations, (b) a manual for the tire management and control system, (c) the new measurement systems and its use as an input for the incentive program, (d) checklist tools in the maintenance process, and (d) "Performance Policies for Drivers Performance", where the criteria for awarding and sanctioning drivers are specified.

Based on the current status of the implementation of the strategies that were developed in this study, table 6 identify further actions to undertake to continuously improve the performance in fuel efficiency.

Table 6. Actions for further improvement

Strategy	**Implementation status**	**New Actions to further improvement**
Value to maintenance	Elimination of repeated activities	Automation and training New purchasing strategies. Inventory analysis is required.
Reward system	Policies approved	Parameters evaluation: First trial duration: one semester Initial attitude assessment to posterior comparison.
Measurement system	Running scheme	Training and visualization
Additives	Pilot	Expansion schedule to all fueling stations
Tire calibration	Proposal under study	Implementation: purchasing and installation

7 Conclusions

Following the PCDA methodology, the team found around 80 symptoms and 5 root causes; repetition of activities in the maintenance area, incentive program for inefficient operators, measurement process for budget and poorly established performance, an old fleet and a lack of control process in tire management. By studying, prioritizing and comparing possible solutions, the team redesigned the measurement system, improved the maintenance process,

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developed a system of rewards for drivers and implemented process of additives in fuel and assurance of calibration and balancing of tires. Based on pilot tests results, simulations and estimations based on experiences found in the literature, it expected an increase of 3.1% in the fuel efficiency of the federal fleet of the company under study.
Besides a practical description of a continuous improvement project, along this paper we described how research findings in fuel consumption reductions, empirical findings in fuel consumption estimations, together with the application of financial, statistical, simulation, quality and logistics tools, lead to the achievement of the objectives, and discover a set of more possibilities for improvement.

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