Reducing customers wait time for repairs in the service department at C-Auto in Puerto Rico.

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Abstract

C-Auto is an automotive dealership. It sells and provides service for vehicles from American, Japanese, and Korean origin. Customers regularly visit to perform a maintenance, a repair and/or a recall. The department receives around 2,300 customers monthly. Currently customers are not satisfied with the wait time of vehicle repairs, with a 54% satisfaction level. Focusing on strategies to reduce customers wait time is the main goal as the dealer wants to increase customers visits to the service department. The main objective was to reduce the average days it takes to repair a vehicle from 6.02 days to less than 5 days and increase the 54% customer satisfaction levels. After implementing a new organization of the space, focusing of what is important for the customer and improving the overall safety and equipment of the employees, the objectives set for the project were reached and exceeded.

Keywords
Lean Manufacturing, Operations Management, Change Management, Kaizen

1. Introduction

The C-Auto service Department receives around 2,300 customers monthly. Customers are not satisfied with the time it takes to get their vehicle repaired. The current Customer Service Index (CSI), in Fig. 1 reflects this perception, as only 54% of customers are satisfied with current service. The current average wait time for a vehicle repair is 6.02 days. Furthermore, for each vehicle that is longer than 5 days waiting for a repair, C-Auto must provide a rental vehicle, reducing profits each day it takes the vehicle to be repaired.

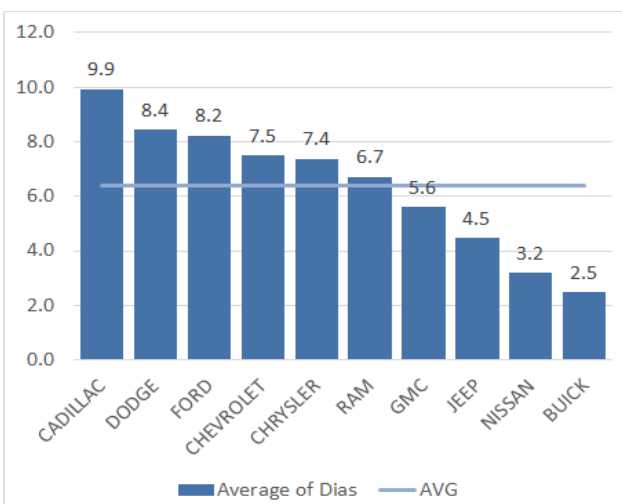


Figure 1. Average repair days per product family

Management wants to increase productivity, customer satisfaction, and enhance customer experience. The solution must be a well-designed streamlined process including SOPs, detailed responsibilities for each position, performance metrics and better communication practices.

1.1 Objectives

The project team established two objectives for the project:

1. Reduce the average wait time from 6.02 days to ≤ 5 days
2. Increase productivity by 10%.

These objectives were developed using the Critical to Quality tree, in Figure 2, translating the customer needs to technical requirements which can be measured and monitored as metrics.

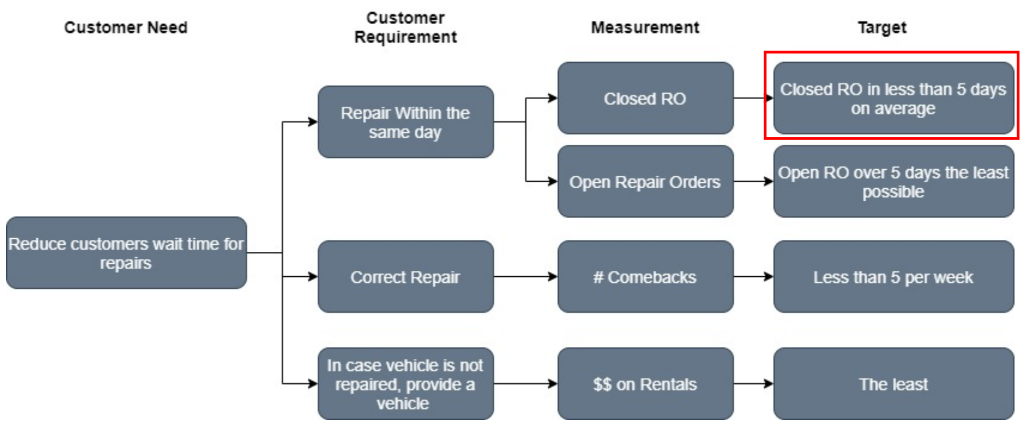


Figure 2. CTQ Tree

2. Literature Review

Increasing productivity in a business or industry allows companies to grow and gain competitive advantage (Niebel, 1988). That is why similar approaches to service applications, including car dealerships are included in this section. To perform improvement activities, the right tools are required. IE and Lean tool used in this paper are also defined. More detail in these topics is shown next.

2.1 Automotive industry and the need for process improvement

Car sales and services are in high demand in Puerto Rico, as vehicles are the only reliable mean of transportation in Puerto Rico. The challenges that come up daily with new technology, inventory constraints, and lack of personnel demand that the service department maximizes the effort to meet customers' expectations. Historically the service department has focused on billable hours, the way production is measured in car repair industries. As customers' expectations and needs have become greater, customer retention can suffer. A mindset of continuous improvement or a customer-centric will be needed if the customer's needs are to be achieved. Using lean six sigma methodology has been proven successful in many manufacturing and service applications (Yadav et al, 2019) There is evidence of application of these techniques to a car dealership in Puerto Rico with excellent results (Cabrera et al, 2021).

2.2 IE and Lean Tools

Some of the process improvement approaches included in this paper include:

- 5S is defined by Randhawa and Ahuja (2017), as a methodology that results in eliminating production wastes, due to process execution, and resource management. The final product is a clean, safe, and well-organized workplace that optimizes productivity.

- Value-added flow analysis specifies what adds value to a productive activity, by transforming an asset and making it with supreme quality for a customer willing to pay. The elimination of non-value-added activities has been presented by Hidayati, Tarigan and Tarigan (2019) and others.
- Analysis of variance, or ANOVA compares the mean of two or more groups to determine if a relationship exists between them (Montgomery, 2011). Two conclusions are possible in this test: all means are equal, or at least one of the means is different. There exist non-parametric tests to make comparisons when one of more of the samples is not normally distributed.

3. Methods

The project was guided principles of the DMAIC methodology. The steps to achieve the objectives include:

1. Historical data was gathered from the database system (DBS) to establish baseline.
   a. Data collection plan
   b. Lift Audit Results
   c. Value added flow analysis by observing mechanics vehicle repair process.
   d. 5S audit for the repair shop
2. Root cause analysis: fishbone + 5 whys to understand and obtain the root cause.
3. Recommendations from:
   a. Value added flow analysis
   b. Parking closeness analysis and redesign
   c. Area facilities redesign
4. Validate using an ANOVA to find the difference in means between the initial number of days it took to repair a vehicle with the new process.
5. Results were analyzed using Engineering Economic principles (Blank and Tarquin, 2012).

4. Data Collection

The data collection plan is shown in Table 1. It included details on data source and use for project

Table 1. Data Collection Plan

ID	Performance measure	Sample size	Data source	Use
1	Open RO days	359	DMS System	Evaluate the current distribution of vehicle waiting for repairs
2	Closed RO Days	9916	DMS System	Determine the time it takes for a vehicle to be repaired
3	Physical Inventory	565	Counting parking spaces	To evaluate the current organization of the inventory and perform a closeness analysis
4	Current lifts evaluation	48	Evaluation and documentation of lift condition	To evaluate the current condition of the equipment that is most important for safety and performance of the mechanics
5	Lift work sampling	173	Go to each car lift and look at the current use of it	Identify the current utilization of the car lifts and look for opportunities for use
6	5s evaluation	3	With a standardize document stating all the 5s important measurements.	Establish a baseline and construct a plan for improvement

An inspection of the car lifts was made to determine the percentage of usable equipment. Figure 3 shows the vehicle lift that need to be repaired in orange, the lifts that need to be replaced in red and the lifts that are on acceptable conditions in gray. It was found that 88% of vehicle lift are not in optimal conditions, 83% of the lift presented rust in the columns and in 50% of the lift the safety locks are not operating.

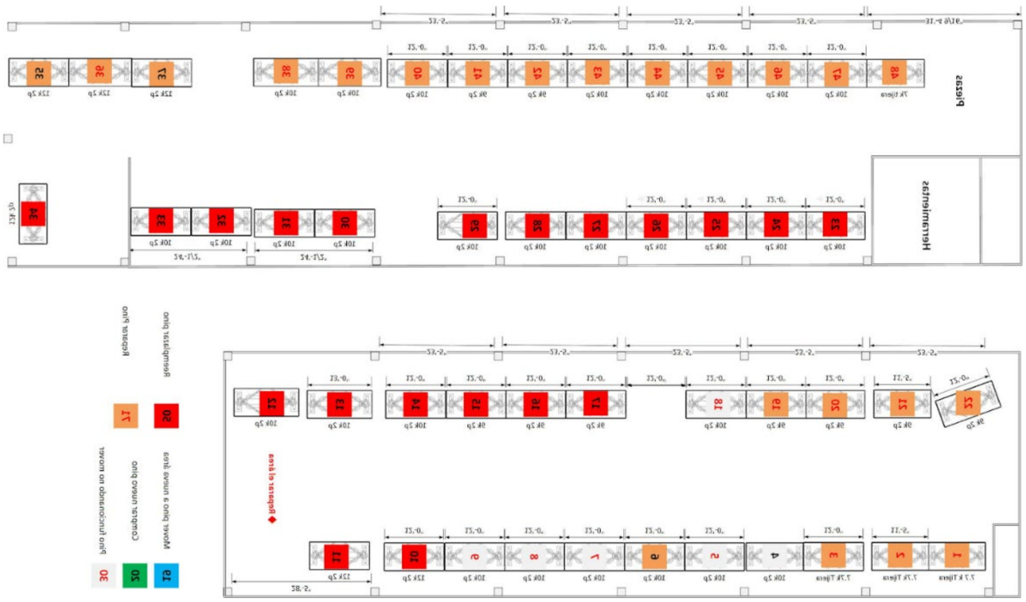


Figure 3. Lift audit results

4.1 Organization and Cleanliness (5s Evaluation) Problem

The images in Fig. 4 are show cleaning and organizing are not ingrained in company culture and not part of the work schedule. Two initial 5s evaluations can be reviewed in Figure 5, and show there are areas of opportunity, as scores of 25% and 30% were obtained.

Figure 4. Service organization before improvement

5s Taller de Servicio

Area de trabajo: Clave: Use la hoja para calificar el área de trabajo (anote cada fecha) 1 = "inexistente", - 3 = "promedio" y 5 = "excelente"

5s Fase	Definicion	Estándares a cumplir	Calificaciones					Proximos Pasos
		Fecha de evaluacion	9/1	10/14				♦Fotos
Sort (Seiri)	Solo los materiales adecuados estan disponibles y todo lo innecesario esta eliminado	- Piezas, herramientas y equipos no utilizados retirados	2	2				♦*Herramientas, tornillos, recipientes, cajas y otros equipos estan en todas las areas de trabajo* ♦ **Se tiene que comenzar a limpiar y organizar las mesas de trabajo**
		- No hay equipo o piezas en los pasillos que impida el flujo.	2	2				
		- No se guarda ningún exceso de inventario	1	2				
		- No hay letreros obsoletos en las paredes.	2	2				
Set in Order (Seiton)	Hay lugar para todo y todo está en su lugar	- Los estantes tiene etiquetas o imágenes claras para las piezas.	1	1				♦No hay un lugar indicado para cada equipo necesario ♦ **Se tiene que comenzar a limpiar y organizar las mesas de trabajo**
		- Los pisos están marcados para indicar la ubicación del equipo.	1	1				
		- Las ubicaciones de las herramientas están marcadas o con borde sombreado	1	1				
		- Las cosas no se dejan tiradas, se guardan	2	2				
Shine (Seiso)	Todo está limpio y en funcionamiento	- Todo el equipo está limpio y pintado para mostrar fugas.	1	1				♦Mesas de trabajo, pinos, piso ,computadoras no estan limpios ♦ **Se tiene que comenzar a limpiar y organizar las mesas de trabajo**
		- Los cables están agrupados y no hay cables sueltos	2	2				
		- Las herramientas y los suministros de limpieza están fácilmente disponibles	1	1				
		- Todas las superficies están libres de suciedad y mugre	1	1				
Standardize (Seiketsu)	Se establecen pautas y prácticas para mantener los primeros tres pasos	- Las actividades y ubicaciones de las 5S están claramente descritas	1	1				♣No hay letreros de auditorias ni resultados ♦ **Se tiene que comenzar a hacer evaluaciones semanales y compartir resultados con el personal**
		- Se están utilizando formularios de auditoría y listas de verificación.	1	2				
		- Hay un horario de 5 y las responsabilidades son claras	1	2				
		- Las cantidades y los límites están claramente marcados	1	1				
Sustain (Shitsuke)	5s es un hábito que las personas incorporan en su práctica diaria	- El liderazgo refuerza los hábitos diarios de las 5S	1	2				♣No es parte de la cultura mantener todo organizado y hacer evaluaciones constantes ♦ Se tiene que comenzar a discutir las evaluaciones y planes mensualmente con los lideres
		- Existe responsabilidad por la práctica continua de las 5S	1	1				
		- Los resultados de las 5S se muestran de forma destacada	1	1				
		- Los empleados están capacitados en 5S y lo reconocen	1	2				
		Puntuacion	25	30	0	0	0	

Figure 5. 5s evaluation

5. Results and Discussion

A Fishbone diagram was designed to analyze the Area Low Efficiency problem. The causes considered were management, man, process, measurement, machine, and methods. It is perceived that the main cause for the effect is that there is not an implemented standard for more than one aspect of the area reviewed.

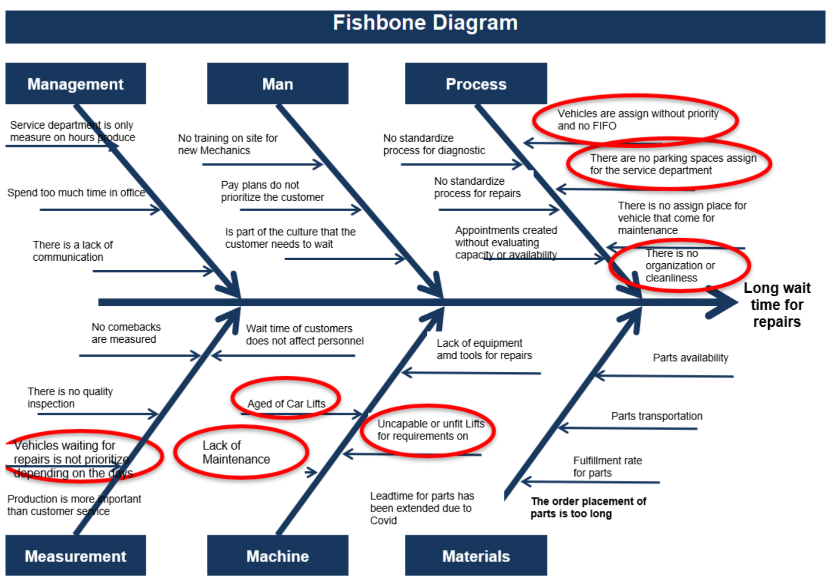


Figure 6. Fishbone diagram to identify root causes

From the root cause analysis, the main opportunities were identified and shown on Table 2.

Table 2. Opportunities found from the root cause analysis

Number	Opportunity	Category
1	Aged Car Lifts	Equipment
1	Lack of Maintenance to all equipment	Equipment
1	Uncapable or unfit Lifts for requirements on vehicles	Equipment
2	There are no parking spaces assign for the service department	Process
2	There is no organization or cleanliness	Process
3	Vehicles waiting for repairs is not prioritize depending on the days	Process
3	Vehicles are assigned without priority and no FIFO	Process

5.1 Numerical Results

The value-added flow was performed, with the non-value-added activities eliminated, as seen in Fig. 7. Tasks removed included waiting for greeting the customer and searching for and alerting service completion. Total cycle time for a repair was reduced from 2157 to 390 minutes, an 80% improvement.

Value-Added Flow Analysis

Name: Joshua Rodriguez — **Process Name:** Assignment and repair of vehicles

Date: 21-Dec — **Time Measured In:** Minutes Hours Days (select units)

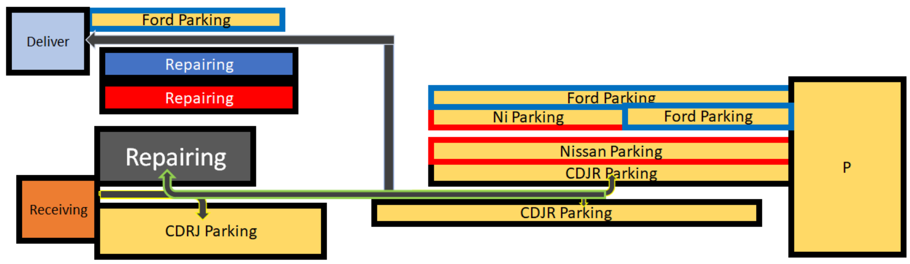
#	Process Step	Step Label (VA, NVA, NVAr)	Value Added Time	NVA & NVA-Required Work Time	NVA - Wait Time
1	*Greeter parks vehicle in available parking space*	NVA		*2.00*	
2	Greeter takes the car keys to the key handler in the tools storage	NVA		5.00	
3	Supervisor reviews the customer complain	VA	4.00		
4	Supervisor assigns vehicle to car mechanic that is available to repair a vehicle depending on the received date If there are no mechanics wait for one to be available	VA	2.00		
5	Mechanic selects vehicle that has been assigned to him	VA	4.00		
6	Mechanic looks goes to the tools storage to ask for key from the key handler	NVA			6.00
7	Parked vehicle waiting for repair	NVA			258.00
7	Mechanic looks for vehicle on the parking spaces	NVA-r		7.00	
8	Mechanic repairs the vehicle	VA	83.00		
9	Mechanic parks vehicle in available parking space	NVA-r		4	
10	Mechanic updates the database system and notifies the supervisor that the vehicle is repaired	NVA-r		15	

	Time	% of total
Total Value-Added Work Time	93	23.85%
Total Non-Value-Added or NVA-r Work Time	33	8.46%
NVA - Wait Time	264	67.69%

Figure 7. Value added analysis for the assignment and repair of vehicles

5.2 Graphical Results

A closeness evaluation, assigning and restructuring the parking spaces time is shown both in Fig. 8 and Table 3. Assigning 8.5 feet for each parking space, the total available spaces equal to 334 or 2839 feet. By changing the configuration of the parking spaces the total distance can by reduced 940ft (-23%) and travel time by 204 seconds (-23%).



CDRJ Example	Colors	Max Dist. (ft)	Time(s)	New Layout	Colors	Max Dist. (ft)	Time(s)	%
Store for repair		987	215	Store for repair		697	152	-29%
Move to repair		969	211	Move to repair		751	163	-22%
Move repaired		969	211	Move repaired		751	163	-22%
Deliver		1100	239	Deliver		886	193	-19%
Total Distance		4025	875	Total Distance		3085	671	-23%

Figure 8. Closeness evaluation

Table 3. Parking space analysis

Brand	Vehicles in stock	Required Space in feet	Available Spaces	Available space in feet
CDJR	136	1156	149	1266.5
Nissan/GM	56	476	72	612
Ford	121	1028.5	113	960.5
Total	313	2660.5	334	2839

5.3 Proposed Improvements

Recommendations for lifts will consider worker safety minimizing potential occupational risks. These recommendations are shown in Table 4 and include repair, maintenance, and replacement activities.

Table 4. Proposed solutions for car lifts

Solutions	Costs	Advantage	Disadvantage
Repair only lifts on critical condition (22)	$23365	Less Expensive than repairing all lift	Potential fines and lawsuits due to accidents
		Improves the performance and safety of part of the lifts	Performance can be affected due to breakdown
Maintain the same lifts until they break	$0	No required investment	Potential fines and lawsuits due to accidents
			Performance can be affected due to lifts breakdown (Downtime)
			More expensive to buy and replace each time a lift is broken (approx. $1000 more)
Replace and repair all lift to be certified (42)	$83420	Improves the performance and safety for all employees	More expensive than the other solutions
		Reduces or eliminates risk of potential fines and lawsuits due to accidents	Slow down production while lifts are repaired
Hire personnel to do a monthly and annual maintenance and inspection	$9600	It improves the useful life of car lifts + Identifies potential breakdowns and solves before it breaks	Additional cost and reliability of suppliers is not the best

A cleaning day was agreed, with before (Figure. 9) and after (Figure. 10) results shown next.

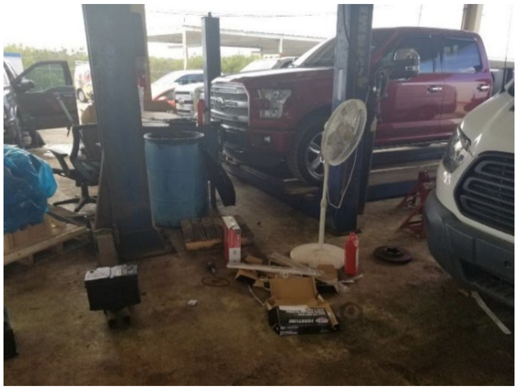


Figure 9. Repair area Before

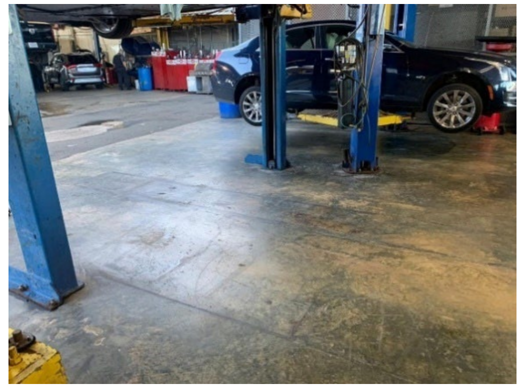


Figure 10. Repair area on cleaning days

To maximize the space and reduce non-value added activities related to movement and sustain the 5S initiatives, the stations were reorganized with these recommendations.

- Rotate tables and separate half for each side.
- Create 4 corridors for mechanics to move and assign one space for each mechanic
- Standardize the required equipment for each workbench

The proposed station design is shown on Fig. 11.

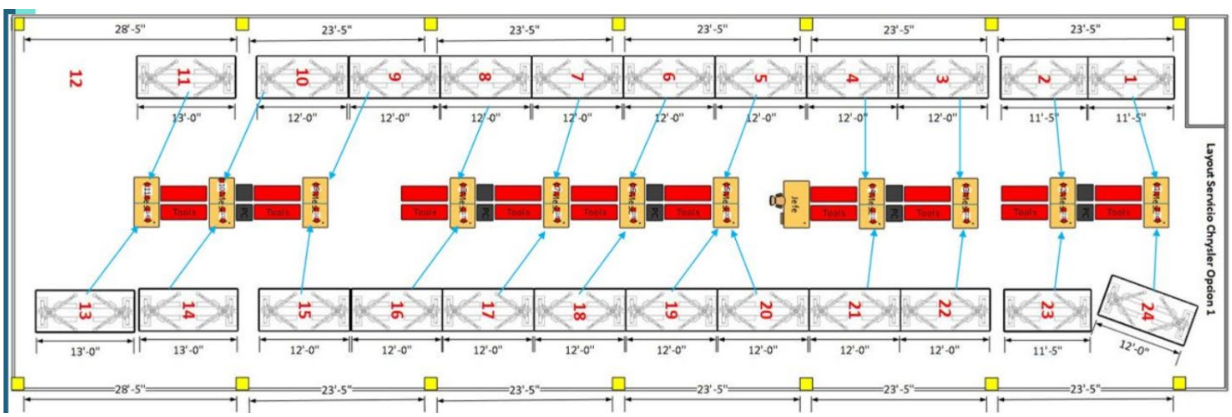


Figure 11. Proposed area redesign

5.4 Validation

An Anova test was performed, as seen in Fig. 12, to evaluate if mean service time has improved. Since the p-value is less than the 0.05 significance level, the average days a vehicle waits for a repair has been reduced, meeting one of the project objectives.

Method

Null hypothesis	All means are equal
Alternative hypothesis	Not all means are equal
Significance level	α = 0.05

Equal variances were not assumed for the analysis.

Welch's Test

Source	DF Num	DF Den	F-Value	P-Value
Factor	1	17340.5	53.36	0.000

Figure 12. Statistical inference analysis

6. Conclusion

With the application of Lean Six Sigma tools, the service process for C-Auto had improvements in cycle time, repair times, productivity, and flow. The results from this project once again prove that process improvement can be performed in manufacturing and service facilities with ease. Table 5 shows all project objectives were achieved and exceeded. As is the case in many projects, improvement is continuous, and more activities to further make the process better remain to be done.

Table 5. Objective review table

Objective	Target	Before	Achieved
Reduce the number of days it takes to repair a vehicle	5 days	6.02	4.3
Increase productivity by 10%	3,900	3410 (70%)	3912 (80%)

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Biographies

Joshua Rodriguez Zayas has bachelor's degree in Industrial and Engineering from the Ana G. Méndez University, Puerto Rico. Currently holds LSS Green Belt certification. The main areas of interest are process improvements, lean six sigma, customer service improvements, sales increments, and project management. Aside from the engineering field study, he has worked as a high school math teacher for around 5 years and a sales manager for a call center for around 3 years.

Jannette Pérez Barbosa, PE is an assistant professor in the Industrial and Management Engineering program at Ana G. Méndez University, Puerto Rico. She has bachelor's and master's degrees in Industrial Engineering from the University of Puerto Rico, Mayagüez, and is currently completing a Ph.D. in Systems Engineering from Colorado State University (CSU). As the Senior Design Project (Capstone) instructor, her students' projects have been recognized for their excellence in engineering competitions in Puerto Rico. In 2021, a group of her students participated for the first time in the IISE Design Project Competition. She is a licensed engineer and the coordinator of the FE and PE exam reviews for Puerto Rico's engineering association (CIAPR). Her research interests include decision-making methods, engineering education, and process improvement. She was recognized as UAGM's Distinguished Engineering Professor in 2018 and IISE's Southeast Region Outstanding Faculty Advisor in 2021. She is also 2020 CIAPR's Distinguished Industrial Engineer. Her previous engineering experience includes roles as a Technical Service Specialist, Statistician, and Industrial Engineering team leader at Pfizer, where she received several site and corporate awards. Additionally, she has served as a trainer and consultant for several manufacturing and service companies on the island.