Increase of the number of internal trips in a steel company: A case of study

Ricardo Adrián Cisneros Hernández
Engineering Department
Universidad de Monterrey
San Pedro Garza García, 66238, N.L.
ricardo.cisneros@udem.edu

Diana Paola Morales Mata
Engineering Department
Universidad de Monterrey
San Pedro Garza García, 66238, N.L.
diana.morales@udem.edu

Erick Humberto Garza-Espinosa
Engineering Department
Universidad de Monterrey
San Pedro Garza García, 66238, N.L.
erick.garza@udem.edu

Jenny Díaz-Ramírez
Engineering Department
Universidad de Monterrey
San Pedro Garza García, 66238, N.L.
jenny.diaz@udem.edu

Abstract

Looking forward to reduce their transportation expenses, the transport and traffic department of a steel company has implemented a system, which consists in a set of circuits developed to achieve a fast, efficient and low cost transportation, with a common origin and/or destination. These circuits have been called clusters. The clusters operate with contracts that prioritize the transport operation to contractors who cover them at a lower price per trip and with volume targets measured in terms of number of daily trips per truck. However, the contractors' expected performance in those clusters has not achieved the established targets for two of the four identified clusters. The objective of this project is to increase the daily trips per truck by 30 percentage points, in clusters one and four. DMAIC methodology was followed to accomplish this objective. For the accepted and implemented proposals, a post indicators vs. base line comparison was made, and for those unimplemented proposals, a discrete event simulation was developed by ProModel program, in order to estimate their impact.

Keywords
DMAIC, Discrete event simulation, Supplier negotiations, Trips increase, Usage effective time.

1 Introduction

Road transportation has become an important factor in international trade and the management of supply chains (Villarreal 2016). Delays and unnecessary transportation can raise freight costs and reduce profit margins. (Bachraoui 2016) Understanding lean concepts is key for identifying waste and optimizing the supply chain without spending a lot of money on new equipment or personnel. In the last decade, however, “lean transportation” has emerged as alternative movement to improve transport operations (Vence 2015). One of the more important Transportation in excess of what is required if inventory and flow exist in the network. This includes underutilized equipment, inter-plant shuttles, trailer demurrage and other transportation wastes (Martichenko 2014).

Transportation allows organizations to deliver the right goods in the right quantity to their customers at the right time, yet excess transportation movement creates waste and added costs to the customer. (Niemelä 2016). Transportation is a necessary component of most businesses and adds value that is recognized by customers; consequently it should be considered a strategic part of any operation (Martichenko 2014).

This Project will develop the theme of transportation, due to a real situation presented in a Mexican steel company, with 5 plants located in San Nicolás de los Garza and Pesquería, Nuevo León. The company has four clusters in Mexico’s north area, which are formed by a routes established with a common origin and/or destination that makes up a travel sequence as presented in Figure 1.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
	• Guerrero-Pesquería • Churubusco-Pesquería • Pesquería-Juventud • Pesquería-Guerrero • Pesquería-Churubusco • Pesquería-Universidad	• Guerrero-Universidad • Guerrero-Juventud	• Churubusco-Universidad • Churubusco-Juventud	• Churubusco-Guerrero • Guerrero-Churubusco
	OBJECTIVE: to meet a certain number of daily trips per truck.			
Goal	**4.0**	**6.2**	**5.5**	**5.7**

Figure 1. Clusters Description.

The clusters were formed through an engineering study developed by the Industrial Engineering department of the company. The study period was three months (from May through August, 2015) and the main objective, daily trips by truck, was determined as follows:

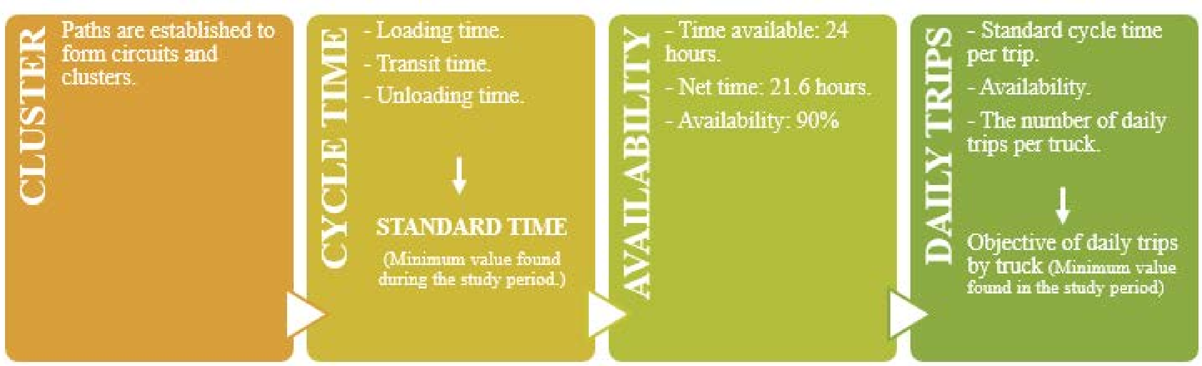


Figure 2. Objective of daily trips by truck

It is important to mention that the whole process for the formulation of the objectives (Figure 2), was developed based in the materials transportation among plant’s needs, establishing origin and destination plants.

1.1 Problem statement

Clusters began their implementation in March, 2016; and since then, their behavior has been followed. The results of these observations are presented in Table 1, where it can be seen that clusters 2 and 3 have reached their stated objectives. On the other hand, the historical behavior of clusters 1 and 4, show less favorable results as long as they are below the proposed target. In cluster 1 and 4, they have an average of 2.83 and 3.69 trips per truck; with targets of 4 and 5.7 respectively.

Table 1. Historic behavior of trips per truck (March 2016 – November 2016).

CLUSTER	Trips per month (average)	Trips per truck (average)	Objective Trips per truck
1	923.22	**2.83**	**4.00**
2	595.00	**6.33**	**6.20**
3	473.11	**5.57**	**5.50**
4	1,081.00	**3.69**	**5.70**

After detecting this area of opportunity in clusters 1 and 4, the behavior of the following factors that interact in them was investigated: a) Loading time, b) Transit time and c) Download time.

Both in cluster 1 and 4, these three indicators present a critical state, in which they are higher than the established standards (except the time of discharge in cluster 1 that is at the limit), therefore they are key points with areas of opportunity, mainly because their impact goes directly to the performance of clusters. This project is defined based in current panorama of the clusters ad their main indicators state.

1.2 Objective

This project objective is to design and implement improvement strategies that allow the company to increase daily trips per truck by 30 percentage points in clusters 1 and 4. This objective is intended to be achieved through: a) reduction of 5 percentage points in loading time, b) reduction of 20 percentage points in unloading time, c) reduction of 10 percentage points in transit time, and d) increase of 15 percentage points in truck's usage effective time.

2 Methodology

The DMAIC methodology was chosen, since it has an analytical and well-structured approach, where each process is carefully analyzed by statistical techniques before implementing or treating improvements. McMarty (2004), defines DMAIC as the "process improvement methodology used by Six Sigma, and is an iterative method that follows a structured and disciplined format based on the hypothesis approach, the realization of experiments and their subsequent evaluation to confirm or reject the hypothesis previously raised"

Berardinelli (2012), mentions that "it is a methodology that is built with the previous steps: define will help to know what to measure, measure will be used to know what to analyze, analyze will let them know what to implement and implement will help to know what has to be controlled". With this, it can be concluded that DMAIC is a methodology that doesn't allow skipping steps, which is crucial for a successful project.

Figure 3 describes how the DMAIC methodology was adapted to the problem. It was divided into four stages in order to achieve a better management, based on each of the stages required by the university and the client.

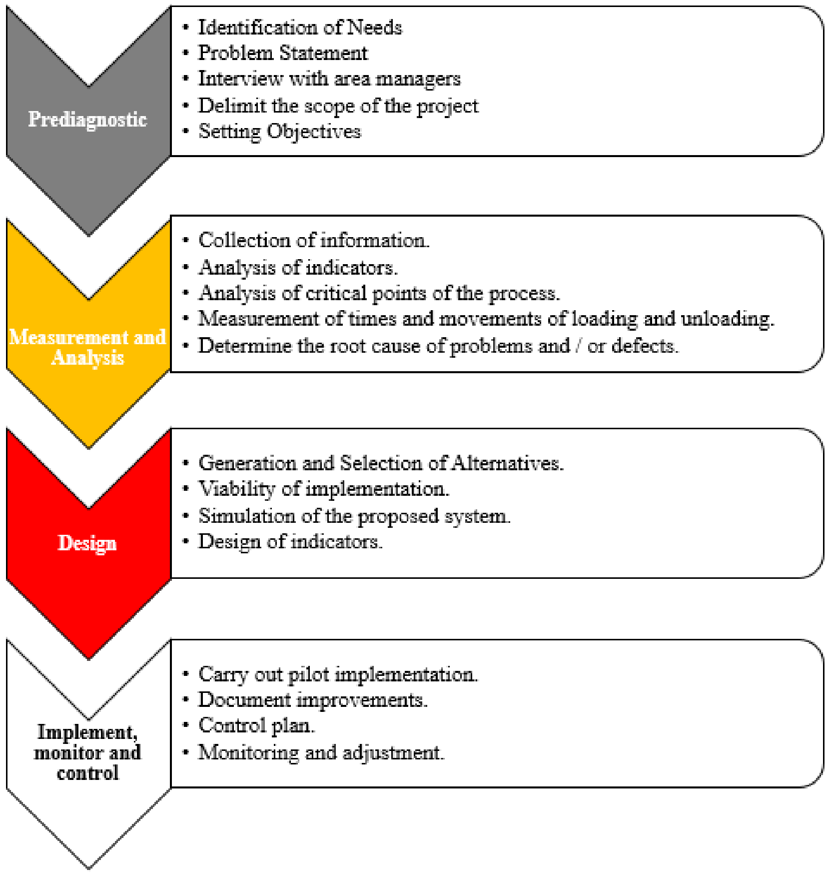


Figure 3. Implementation of DMAIC methodology

3 Analysis

3.1 High unloading times in University Plant

As shown in figure 4, the discharge time is mainly affected by the University plant, since it is 43% above the standard calculated with the data obtained during the study period.

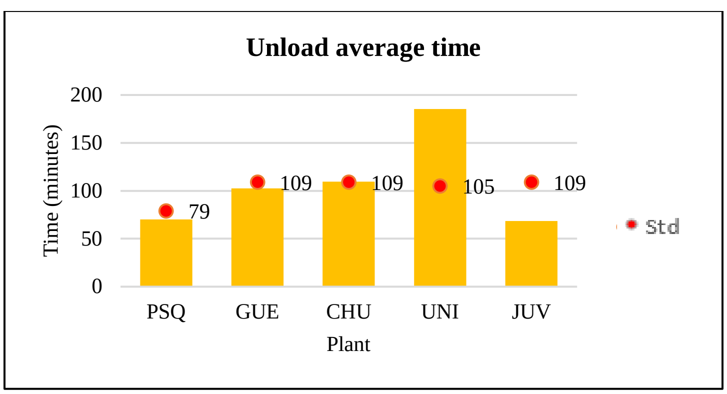


Figure 4. Unload average time

After some field research, it was found that this plant only has one bridge crane, which has three main tasks: supply three production lines, accommodate the rolls and unload the material of the trucks, of which, the priority is the production lines. After analyzing the distribution of its activities through the measurement of times and movements, it was obtained that only a 72% of the time was in use, which divides in a 65% to the priority activity and the accommodation of rolls and only 7% to unload trucks.

3.2 Queues times above the standard in the plants of Churubusco, Guerrero and Universidad

During the analysis, it was detected that loading and unloading time were strongly affected by queues. As can be seen in the figure 5, just Pesquería plant is below the standard; while the other plants do not.

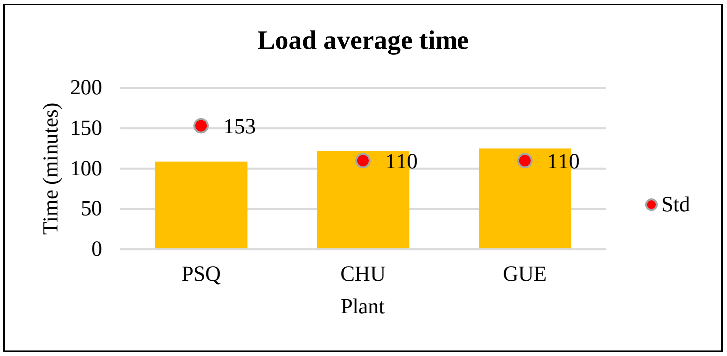


Figure 5. Load average time

After field investigation, it was detected that the trucks of the clusters have preference in the line when they are at Pesqueria, contrary to what happens at the others two plants and Universidad. The procedure to give these trucks preference is to let them enter to load or unload immediately after a platform becomes available. While in the rest of the plants, they have the normal procedure making long queues.

3.3 More than 87% of the routes have higher times than the standard

After analyzing the transit time (see figure 6), it was concluded that all routes from both clusters have an average time greater than the target (with exception of route CHU-PSQ).

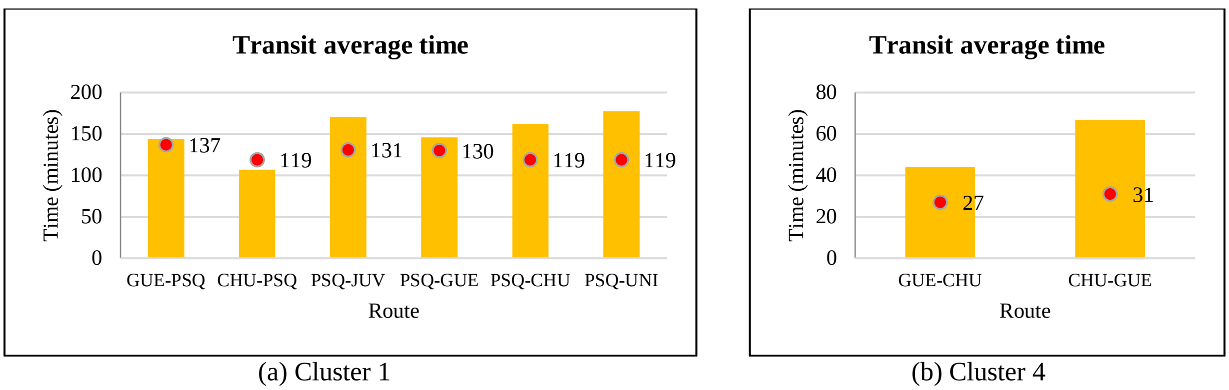


Figure 6. Transit average time

Through the analysis of transit time, it was found that this is strongly affected since there was only one documented and proven route, which at the same time was composed of traffic avenues during certain hours of the day. This delayed the arrival of trucks on almost all routes.

3.4 Low initial activity of loading, unloading, and transit during shift changes

Based on the total time of the trips during the period of study, the effectiveness of the trucks was analyzed. Cluster 1 has an effective usage of trucks of 64%, and cluster 4 of 60%. Whit this in mind, a statistical analysis of the shift changes was developed, obtaining unfavorable results, due to the fact that a low initial activity of loading, unloading and transit, was detected around and during shift changes. An example of the monthly average of trucks that starts loading activity is presented below in figure 7:

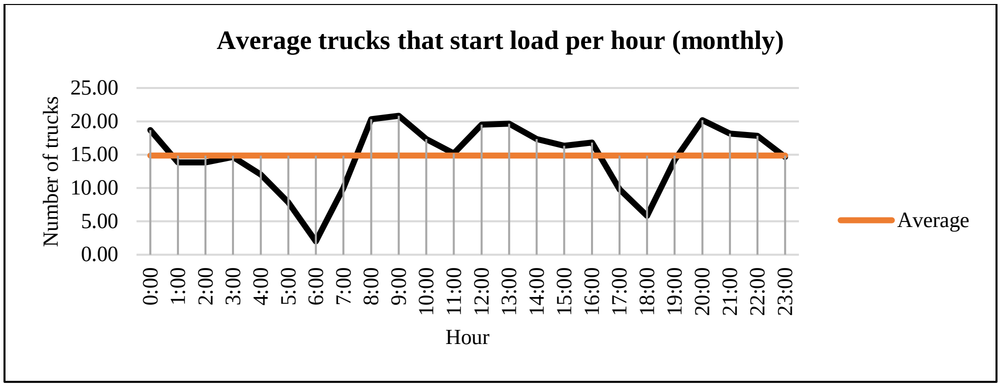


Figure 7. Average trucks that start load per hour in Cluster 1 (monthly).

Figure 7 shows the low activity peaks mentioned above, which occur near 05:00 - 08:00 hours and 17:00 – 20:00 hours (corresponding to shifts changes). This has a direct impact on queues along with the accumulation of the start-up activities in the high peaks.

Table 2. Root causes.

INDICATOR	PROBLEM	ROOT CAUSE
Loading and unloading time	High unloading times in University Plant.	The University plant only has one crane, which supplies the loading and unloading processes, and feeds three production lines.
	Queues times above the standard in the plants of Churubusco and Guerrero.	The plants of Guerrero, Universidad and Churubusco, do not have priority in the queues for the processes of loading and unloading.
Transit time	More than 87% of the routes have higher times than the standard.	Only exist one route per plant for the trucks.
Usage effective time	Low initial activity of loading, unloading, and transit during shift changes.	There is a low start-up activity close to and during change shifts.

4 Design

Improvement solutions and strategies were designed for each main root causes that were inducing the trucks not to meet the target of trips per day. These solutions were proposed by the team, discussed with both the academic advisor and validated by the contacts in the company.

Table 3, from left to right, summarizes the indicator that needs to be increased or decreased, the main offender(s) (i.e. root cause), the improvement strategies, and finally, the objectives that are being achieved with each of these.

Table 3. Root causes and strategies matrix.

	ROOT CAUSES	STRATEGIES	OBJETIVES
Loading and unloading time	The University plant only has one crane, which supplies the loading and unloading processes, and feeds three production lines.	Financial proposal of traveling crane.	• **Reduction of 20 percentage points in unloading time.** • **Reduction of 5 percentage points in loading time.**
	The plants of Guerrero, Universidad and Churubusco, do not have priority in the queues for the processes of loading and unloading.	Priority in queues for cluster trucks.	

Transit time	Only exist one route per plant for the trucks.	Design of alternate routes.	• **Reduction of 10 percentage points in transit time.**
Usage effective time	There is a low start-up activity close to and during change shifts.	Design of multiple shifts by means of statistical simulations.	• **Increase of 15 percentage points in truck's usage effective time.**

4.1 Financial proposal of traveling crane

Based on the fact that only 7% of the time is used for the unloading of material from the trucks, and with the objective of impacting in this indicator, it was determined the elaboration of a financial proposal for a bridge crane; from which it is seek to obtain the impact on benefits through a financial analysis and ProModel simulations. To evaluate whether the proposal is cost-effective, the following indicators were used:

- Minimum Attractive Rate of Return (MARR): Is the minimum rate, established by the company, to accept the project
- Useful life in years: It is the number of years in which the project will be evaluated. This amount depends on factors such as the useful life of the machinery to buy and is very important to calculate the amortization
- Net Present Value (NPV): Is the difference between the present value of cash inflows and the present value of cash outflows. This one is used to analyze the profitability of a projected investment.
- Internal Rate of Return (IRR): It is the rate of interest that an investment offers, in other words, it is the rate at which the net present value equals to 0.
- Payback period at present value (years): It is the time required to cover the cost of the investment taking into consideration the net present value.

4.2 Queue priorization

To solve the problem of high loading or unloading times, the strategy used in Pesqueria was replicated for the rest of the plants involved. Firstly, an analysis of the alternatives to give priority to the cluster trucks was made, taking care of meeting with safety, logistics and general procedures. In order to comply with the standards of the mentioned areas, a safety suit for the drivers was design and the trucks were distinguished from another's to be more easily recognized by the area managers. Merely in terms of logistics, the trucks waited at strategic points to be the next to enter to the platform ones it is empty. For this to happen, multiple scenarios were simulated through ProModel, which seeks to obtain the impact and benefits of this strategy.

4.3 Alternate routes

Once the analysis was done, alternative routes for each of the routes of the cluster was made. In order to do this, tools like Google Maps, Waze and the approved regulation of transit were used. To obtain the best alternatives, routes were designed for different schedules, taking in consideration facts like time in rush hours, regular hours and kilometers traveled. As a result of the alternatives, routes in which one or more available options that improved the times were found, that depending on the time the trucks left the plants. These alternatives were given to each of the drivers for their implementation

4.4 Multiple shift changes

For the design of this strategy, the main objective was to decrease the variance that existed throughout the day with the low starting peaks of activities before, during, and after shift changes. For this reason and looking for the distribution of beginning of the activities, it was proposed the implementation of changes in step shifts, for it a series of simulations were performed through Excel, where reductions in variances were obtained. The step shifts consists of scheduling the changes in two different groups, where one part of the group changes to one hour, while the other part does two hours later. This in order to avoid low activity in periods of the day, as well as to reduce long queues of trucks looking to realize a same activity at a same time that would generate time lost for some units. With the simulations, it was possible to obtain that the ideal scenario was that half of the trucks in both clusters made the change of shift at 5:00 a.m and 5:00 p.m., while the rest would starts at 7:00 a.m. and 7:00 p.m.

5 Results

The implementation of the full previously described strategies is currently under way after the pilot run validated such strategies. The organization started the implementation with the priority in queues for cluster trucks. This action contributed to the increase of the average of the internal trips per day because it eliminates the bottlenecks in the warehouses (Figure 8 & 10).

5.1 Loading time

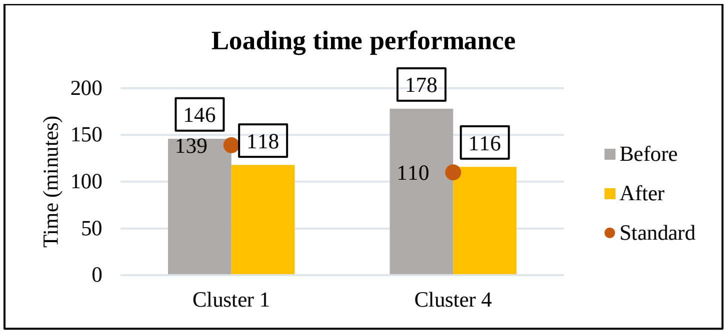


Figure 8. Loading time performance.

In figure 8, is shown the comparison of the average time of loading when the project started against the current one, where this last scenario presents a decrease of 19% in cluster 1 and 35% in cluster 4. These results achieve that the loading time in Pesquería, Churubusco and Guerrero plants reduce in average up to 27%. Results from cluster 1 get the process time to be located 15% below the standard. However, for cluster 4, although its impact was greater, it is 6 minutes (5%) above its standard.

5.2 Transit time

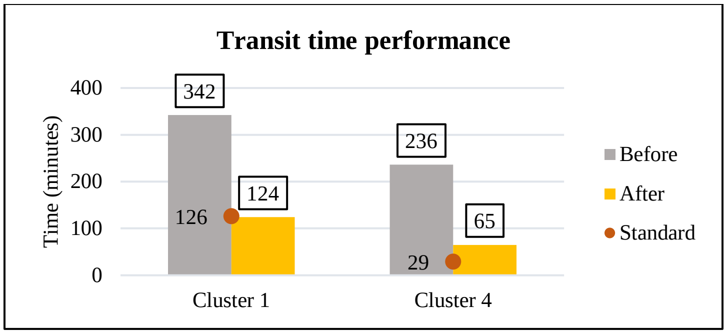


Figure 9. Transit time performance.

Talking about transit time, the impact is greater than the one presented in loading time, since it reaches an average decrease of 68%: 64% in routes from cluster 1 and 73% in routes from cluster 4. Although cluster 4 presents a greater impact, only cluster 1 achieves the established target time, getting 2% below the standard time.

5.3 Unloading time

Figure 10 shows that there is a reduction of 10% in cluster 1 and a 4% in cluster 4. Altogether, this achieves an average decrease of 7% in the process time in Pesquería, Guerrero, Universidad, Churubusco y Juventud plants.

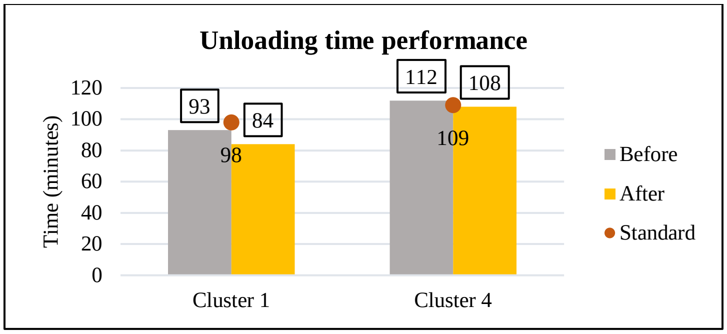


Figure 10. Unloading time performance.

5.4 Truck's usage effective time

Finally, regarding to truck's usage effective time, in figure 11 is presented a favorable result, in which cluster 1 presents an increase of 18% and cluster 4 a 13%, obtaining an average increasing impact of 16%, thus achieving one of the particular objectives of this project.

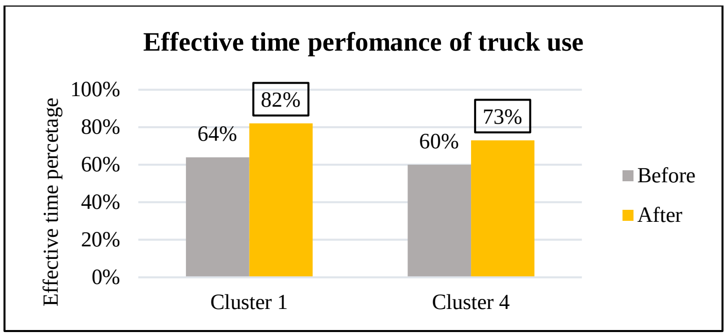
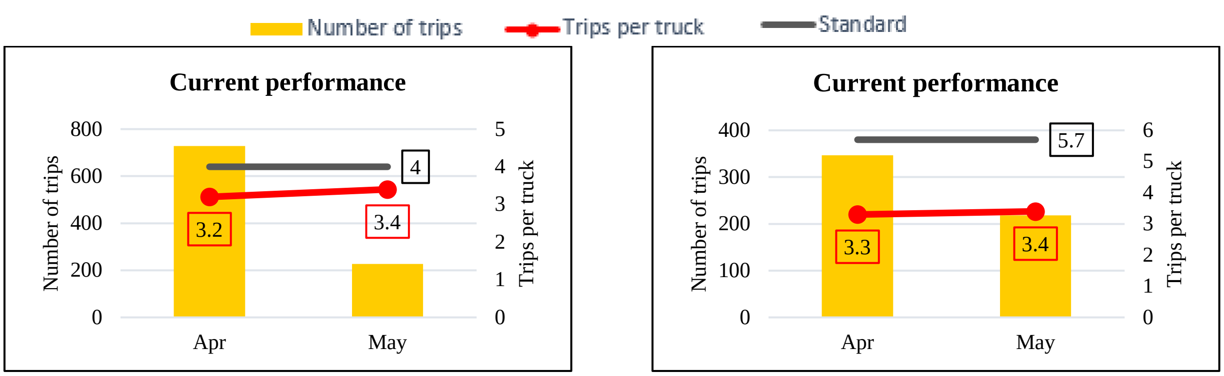


Figure 11. Effective time performance of truck use.

5.5 Trips per truck

Figure 12 shows the main indicator for the clusters, which represents the main objective of this project.



(a) Cluster 1 (b) Cluster 4

Figure 12. Clusters performance.

Been favorable in comparison with the results from the last three months of the research. In cluster 1, at present, the truck achieves an average of 3.3 trips per day; while its prior average was 2.84. This refers to an increase of 16.2% in the daily trip by truck. On the other hand, cluster 4, achieved an increase of 14.3%, previously their trucks averaged 2.93 trips, and today they reach an average of 3.35. Finally, it should be mentioned that the trend in both clusters is favorable, since the number of daily trips per truck tends to increase.

5.6 Multiple shift changes

This strategy was implemented during the pilot test from April 10 to May 11, in which an even more favorable result was achieved than in the simulations. A total decrease of 56% of the variance was obtained, resulting in effects on the queues, loading and unloading times, and therefore an increase in the main objective.

5.7 Financial Proposal

The table 4 shows the result of the financial proposal for the crane, which helps the company to make a decision.

Table 4. Financial Proposal

Project evaluation	Accept
Useful life in years	15
Net Present Value (NPV)	1,987,069
Net annual value (NAV)	407,532
Minimum Attractive Rate of Return (MARR)	19.0%
Internal Rate of Return (IRR)	26.75%
Payback period at present value (years)	6.7

The proposal shows a favorable result for the investment of the company, since the IRR is greater in almost 40% to the MARR, which is the minimum rate for which the project could be accepted. As a result, there would be a considerable reduction in the discharge times of the University plant, which would positively affect the whole group with an increase in the number of trips.

5.8 Simulation

Table 5 shows the strategies that were implemented by the organization, as well as those simulated by the ProModel program.

Table 5. Implemented and simulated strategies.

	Strategies	**Implemented**	**Simulated**
Cluster 1	Priority in load queues.	x	x
	Priority in download queues.	x	x
	Alternate routes.	x	x
	Multiple shifts changes.	x	
	New traveling crane in University plant.		x
Cluster 4	Priority in load queues.	x	x
	Priority in download queues	x	x
	Alternate routes.	x	x
	Multiple shifts changes.	x	

In order to estimate the impact of the recommended strategies, it was chosen to represent the current situation through a model of discrete event simulation implemented in ProModel®. For cluster 1, six scenarios were simulated, while for cluster 4 there were two. The results as a function of the number of daily trips obtained are presented in table 6.

Table 6. Results of the simulated models.

	Models	**Average daily trips made by cluster trucks**	**% Increase**
Cluster 1	Original model	2.4	
	Simulated model 1 (Priority in queues)	3.5	46%
	Simulated model 2 (2 cranes in plant University)	2.7	13%
	Simulated model 3 (Priority of queues and 2 cranes in Univ. Plant)	3.4	42%
Cluster 4	Original model	3	
	Simulated model 1 (Priority in queues)	4.5	50%

With these results, it can be estimated that when implementing the row priority in all the plants for cluster 1, there would be a 46% increase on trips. Likewise, when implementing the row priority in the plants of Guerrero and Churubusco for cluster 4, there would be a 50% increase on trips.

5.9 Investments and procedural changes

Of the strategies selected, only the number 1 required an investment by the company to buy the crane system. The value of the investment is $ 5,464,188 MXN, approximately 310,178 US Dollars. For the rest of the strategies, procedural changes were made, of which the most significant were:

- Strategy 2 (Priority in queues for cluster trucks): In this strategy the procedure of entry to the plant and the queue of waiting for the loading and unloading of materials was changed. The main change is to stop waiting in line like any truck and skip it being the first to entry to the platforms once it becomes available again.
- Strategy 3 (Alternate routes): For this strategy, previously there was only one route established for each one of the trips without being in several occasions the best option, however, once the project was implemented, each route has alternatives of routes that can be used and that show an improvement in time or distance.
- Strategy 4 (Multiple shift changes): For this strategy, the procedure change focuses on the fact that two shifts were made previously, in which all the pilots did at the same time. Once the project was implemented, there are the same two shifts per day, however, instead of changing everything at the same time, two groups are changed that shift shifts at different times to avoid recording low activity peaks.

6 Conclusions

The case of study presented in this document highlights the contribution made to a major company in the region dedicated to the production of steel products, with the aim of increasing the number of trips in two of the clusters defined by the company. Although the objective presented seems very specific at first sight, the process of analysis involved a holistic understanding of the operations of the transport and traffic department of the company.

The process improvement methodology DMAIC guided the actions involving the application of techniques and basic concepts of industrial engineering. Those goes from descriptive and inferential statistical analysis and process redesign, to implementation of simulation of discrete event models to evaluate the effectiveness of the proposals in a dynamic and uncertainty environment.

The clarity of the exposure of the current situation and the justification of the proposals to the managers in the company allowed several of them to be quickly approved and implemented, so in this report it is possible to observe not only simulated or estimated results but real ones.

7 Bibliography

Azor, J. (2000) Pruebas de hipótesis. Recuperado en febrero del 2017. Puede encontrarse en: http://www.iuma.ulpgc.es/~nunez/mastertecnologiastelecomunicacion/Tema2InferenciaEstadistica/estadistica-y-R/2-hipotesis.pdf

Bachraoui, Yasmine. *Steel Available.* 2016. http://www.steelavailable.com/en/become-a-leader-and-manage-efficiently-your-supply-chain/ (último acceso: 9 de May de 2017).

Bataller, Alfons. La gestión de proyectos. Barcelona, ESPAÑA: Editorial UOC, 2016. ProQuest ebrary. Web. 2 May 2017.

Barrio, J. F. (1997). Las siete nuevas herramientas para la mejora de la calidad. FC Editorial.

Berardinelli (2012) DMAIC or not DMAIC? Recuperado en abril del 2017. Puede encontrarse en: http://asq.org/quality-progress/2012/11/back-to-basics/to-dmaic-or-not-to-dmaic.html

Cruijssen, F., Dullaert, W., & Joro, T. (2010), "Freight transportation efficiency through horizontal cooperation in Flanders", International Journal of Logistics Research and Applications, Vol. 13, No. 3, pp. 161-178.

Dantzig, G.B., & Ramser, J.H. (1959), "The Truck Dispatching Problem", Management Science, Vol. 6, No.1, pp. 80-91.

Fugate, B.S., Davis-Sramek, B. & Goldsby, T.J. (2009), "Operational collaboration between shippers and carriers in the transportation industry", International Journal of Logistics Management, Vol. 20 No. 3, pp. 425-47.

Guan, T.S., Mason, K., & Disney, S. (2003), "MOVE: Modified Overall Vehicle Effectiveness", 8th International Symposium on Logistics, Seville, Spain, July 2003.

Julián Pérez Porto y Ana Gardey. (2012). Varianza y desviación estándar. Recuperado en febrero del 2017. Puede encontrarse en: (http://definicion.de/varianza/)

Márquez, C. (2012) Guía ProModel. Recuperado en abril del 2017. Puede encontrarse en: https://carlosmarquez.files.wordpress.com/2012/02/guia-nc2b01-promodel.pdf

Martichenko, Robert. *Lean Transportation – Fact or Fiction?* 2014. http://leancor.com/wp-content/uploads/2014/03/Lean_Transportation_LeanCor_FedEx.pdf (último acceso: 2017).

McMarty (2004) Integrando la Metodología DMAIC de Seis Sigma con la Simulación de Eventos Discretos. Recuperado en abril del 2017. Puede encontrarse en: http://www.laccei.org/LACCEI2012-Panama/RefereedPapers/RP147.pdf

Muñoz, J (1982) Criterio de detección de outliers en modelos probabilísticos tipo Pareto. Recuperado en enero del 2017. Puede encontrarse en: file:///C:/Users/c.rcisnh/Downloads/984_466_95_7.pdf

Niemelä, Janina. *Outbound transportation management analysis: Case of study.* 2016. https://theseus.fi/bitstream/handle/10024/121645/Niemela_Janina.pdf?sequence=2 (último acceso: 2017).

ProModel (2017) ¿Qué es ProModel?. Recuperado en marzo 2017. Puede encontrarse en: http://www.promodel.com.mx/promodel.php

Pro Model. (2011). Pro Model. Recuperado en abril del 2017. Puede encontrarse en: https://estadisticaccbas.uaa.mx/moodle/file.php/1/ProModel_User_Guide.pdf

Sánchez Sánchez, Ernesto Alonso, Inzunza Cazares, Santiago, and Ávila Antuna, Roberto. Probabilidad y estadística 1. Distrito Federal, MÉXICO: Grupo Editorial Patria, 2015. ProQuest ebrary. Web. 2 May 2017.

Sheldon, R (2007) Introducción a la estadística. Recuperado en febrero del 2017. Puede encontrarse en: file:///C:/Users/c.rcisnh/Downloads/984_466_95_7.pdf

Sergas. (2014). Distribuciones de probabilidad. Recuperado en marzo del 2017. Puede encontrarse en http://www.sergas.es/Saude-publica/Documents/1899/Ayuda_Epidat_4_Distribuciones_de_probabilidad_Octubre2014.pdf

Universidad Nacional del Callao. (2012). Medidas de centralización. Recuperado en marzo del 2017. Puede encontrarse en http://unac.edu.pe/documentos/organizacion/vri/cdcitra/Informes_Finales_Investigacion/IF_JUNIO_2012/IF_CALDERON%20OTOYA_FCA/capitulo%203.pdf

Vence, Carla Di. *Reducing inbound transportation costs: An application.* April de 2015. https://www.researchgate.net/publication/281799978_Reducing_inbound_transportation_costs_An_application (último acceso: 2017).

Villarreal, Bernardo. *Lean road transportation – a systematic method for the improvement of road transport operations.* March de 2016. http://www.tandfonline.com/doi/full/10.1080/09537287.2016.1152405.

Biography

Ricardo Adrián Cisneros Hernández Graduated professional from the University of Monterrey as Industrial and Systems Engineer and certified as auditor in ISO 9001: 2008. He has experience in topics such quality, sales, maintenances, supply chain and human resources.

Diana Paola Morales Mata. Graduated professional from the University of Monterrey as Industrial and Systems Engineer and certified as auditor in ISO 9001: 2008. She has experience in carrying out quality projects, maintenance and transportation.

Erick Humberto Garza Espinosa Graduated professional from the University of Monterrey as Industrial and Systems Engineer and certified as auditor in ISO 9001: 2008. He has experience in topics such production, industrial engineering and quality.

Jenny Díaz-Ramírez professor at the University of Monterrey. She has worked previously as a professor at Tecnologico de Monterrey, Mexico and Pontificia Universidad Javeriana Cali, Colombia. She got a MSc in operations research from Georgia Tech and the PhD in Industrial Engineering from Tecnologico de Monterrey, Campus Toluca in 2007. Her research topics are applied optimization and statistics in topics such as health systems, air quality and logistics.