A Lean Transportation Approach for Reducing Distribution Cost: A Case Study

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Abstract

This work describes the strategy of a Mexican firm to improve its transportation cost of unused truck capacity. This is based on the application of a transportation waste elimination scheme for increasing efficiency in its warehousing and routing operations on a detailed level. The Operational Equipment Effectiveness index used in TPM is adapted to be used as the main performance measure. Availability, performance and quality wastes are identified using Value Stream Mapping of the distribution operations. The implementation of the improvement initiatives is still in progress but pilot test and projected results are provided.

Keywords:
Transportation waste elimination, lean routing, value stream map, transportation efficiency, vehicle routing problem

1. Introduction

The problem of concern in this paper is the reduction of transportation cost. This problem has been treated exhaustively in the academic literature. Two approaches have been used to the goal of reducing transportation cost; the mathematical modelling approach and the efficiency improvement approach. Under the first approach several classical problems have been utilized: The Vehicle Routing problem, the Transportation problem and others. These models have the objective of minimizing cost, time or distance. The efficiency improvement approach is based on the idea of eliminating waste. This work provides a brief description of the application of the efficiency improvement approach.

The scheme is applied to the distribution operations of one of the leading steel Mexican conglomerates located in the northeastern region of the country. The company is experiencing an important level of transportation cost originated by an important level of unused truck capacity (CUTC). Thus, the management of the company developed a strategy for reducing this cost concept by identifying and eliminating waste in its logistics operations. In fact, as it will be further discussed, Simmons et al., (2004) and Villarreal (2012) point out that unused truck capacity is one of the main wastes that determine the level of performance efficiency.

This report consists of five sections. The next section deals with a brief review of the literature on lean transportation. Then, a description of the scheme utilized to decrease waste is described in section 3. The application of this scheme is undertaken in section 4, and section 5 presents a summary of conclusions.

2. Previous research

The improvement of transport operations has been traditionally approached with the use of mathematical modelling, operations research, and simulation methods (Sternberg *et al.*, 2013). Under these, several classical transportation problems

that include the transportation problem (e.g. Yu et al., 2015; Faulin, 2003; Zhang and Yun, 2009) and the vehicle routing problem (e.g. Yu *et al.*, 2013; Lam and Mittenthal, 2013), among others, have been addressed. Using mathematical modelling, operations research, and simulation methods, the main approach used by researchers to improve transport operations has been mainly based on minimising cost, time or distance, and optimising resource utilisation, routes, and transportation/delivery schedules. The improvement of actual road transport operations and activities to gain efficiency is rarely considered under the mathematical modelling, operations research, and simulation methods (Fugate *et al.*, 2009).

Since significant waste and unnecessary costs are normally present in most transportation networks (McKinnon *et al.*, 2003), the application of lean thinking, alongside its principles and tools, has emerged as an alternative method to address the improvement of road transportation. In line with the traditional lean's philosophy of waste elimination, the focus of the so called "lean road transportation movement" lies on identifying and eliminating non-value adding activities, specifically relevant to transport operations, in order to improve the overall productivity and efficiency of a company's logistics operations. Specific research on the utilisation of lean in the road transportation sector is scarce and in early stages (Villarreal *et al.*, 2009). In this context, only a handful of articles have proposed methods or reported a case where transport operations have been improved through the elimination of non-value added activities (Villarreal *et al.*, 2013; Villarreal, 2012; Villarreal *et al.*, 2012; Hines and Taylor, 2000).

Within the limited research undertaken in the field of lean road transportation, two research avenues can be identified, with also a limited number of papers published around them. These areas are: Extending manufacturing wastes to the transportation area and designing improvement schemes of road transport operations

2.1 From production to transportation wastes

The origins of lean can be traced back to the 1930s when Henry Ford revolutionised car manufacturing with the introduction of mass production techniques. However, the biggest contribution to the development of lean thinking principles and tools over the last 50 years came from the Japanese automotive manufacturer Toyota. The central objective of the lean philosophy is the elimination of non-value added activities (Pettersen, 2009), which consequently contributes to the reduction of costs (e.g. Monden, 1998) and increases value for customers (e.g. Dennis, 2002; Bicheno, 2004). In this context, Sternberg *et al*. (2013) adapted the original Toyota's seven common forms of production wastes for the specific application to road transport operations. In this case, Sternberg *et al*. (2013) concluded that only five of the Toyota's wastes applied to motor carrier operations, but waste due to *excess conveyance* and *excess inventory* did not. Instead, Sternberg *et al*. (2013) included *resource utilization* and *uncovered assignments* as part of the transportation wastes derived from Toyota's original production wastes. These will be called the "Seven Transportation Extended Wastes" (STEWs) in the rest of the document.

On the other hand, Mason *et al.* (2001) and Simmons *et al.* (2004) adapted and extended the Overall Equipment Effectiveness (OEE) (Nakajima, 1988) metric, used by the lean's Total Productive Maintenance (TPM) (Nakajima, 1988) approach to measure equipment effectiveness, and developed a new metric called Overall Vehicle Effectiveness (OVE). This metric was used by Simmons *et al.* (2004) for measuring and improving the performance of truck transportations. Later, Villarreal (2012) proposed a modified version of the OVE measure called Transportation Overall Vehicle Effectiveness (TOVE). Unlike OVE, TOVE considers total calendar time instead of loading time. This is due to the fact that waste identification and elimination is related to the transportation vehicles utilised to move products. A comparative illustration of the structures of the OVE and TOVE measures is presented in Figure 1. In summary, although both measures broadly classify transportation wastes into three mutually exclusive elements (i.e. availability, performance and quality losses), TOVE adds the administrative availability element. Hence, it divides the availability component into administrative and operating availability. The wastes associated with the determination of the OVE/TOVE will be identified as efficiency wastes hereafter.

2.2 Improvement schemes of road transport operations

It is well known that transportation is an activity classified by the lean movement as waste that should be, if possible, eliminated (Womack and Jones, 2003; Ohno, 1988). However, in the current globalised market, transportation is a necessary activity to deliver goods to customers. Thus, when mapping a supply chain, unnecessary transportation becomes an important waste to identify, measure, and eliminate. According to Fugate *et al.* (2009) and McKinnon *et al.* (1999), unnecessary transportation problems and waste can be addressed by increasing the efficiency of transport operations. In this context, Hines and Taylor (2000) proposed a methodology, consisting of four stages to eliminate waste. Villarreal *et al.* (2009) reported the application of this methodology in the logistics operations of a Mexican firm leader in the production and distribution of frozen and refrigerated products.

Villarreal *et al.* (2012) also developed a methodology to reduce transport waste by integrating the Just-in-Time approach of milk runs with the traditional operations research approach of developing algorithms to optimise vehicle routing. Additionally, Villarreal (2012) adapted the lean's Value Stream Mapping (VSM) tool to support efficiency improvement programmes in transport operations. He called this adapted tool Transportation Value Stream Mapping (TVSM).

2.3 Brief description of waste elimination scheme

The waste elimination scheme that is applied corresponds to the one developed by Villarreal (2012). As previously mentioned, the Transportation Value Stream Map is one important tool recommended to facilitate the identification of waste.

The initial step of the scheme is the description of the transportation activities in detail complemented by the estimation of the TOVE index. This is achieved by elaborating the Transportation Value Stream Map (TVSM). Once the TVSM is elaborated, the following stage consists of identifying waste at the macro level and particularly looking for opportunities to improve Administrative Availability.
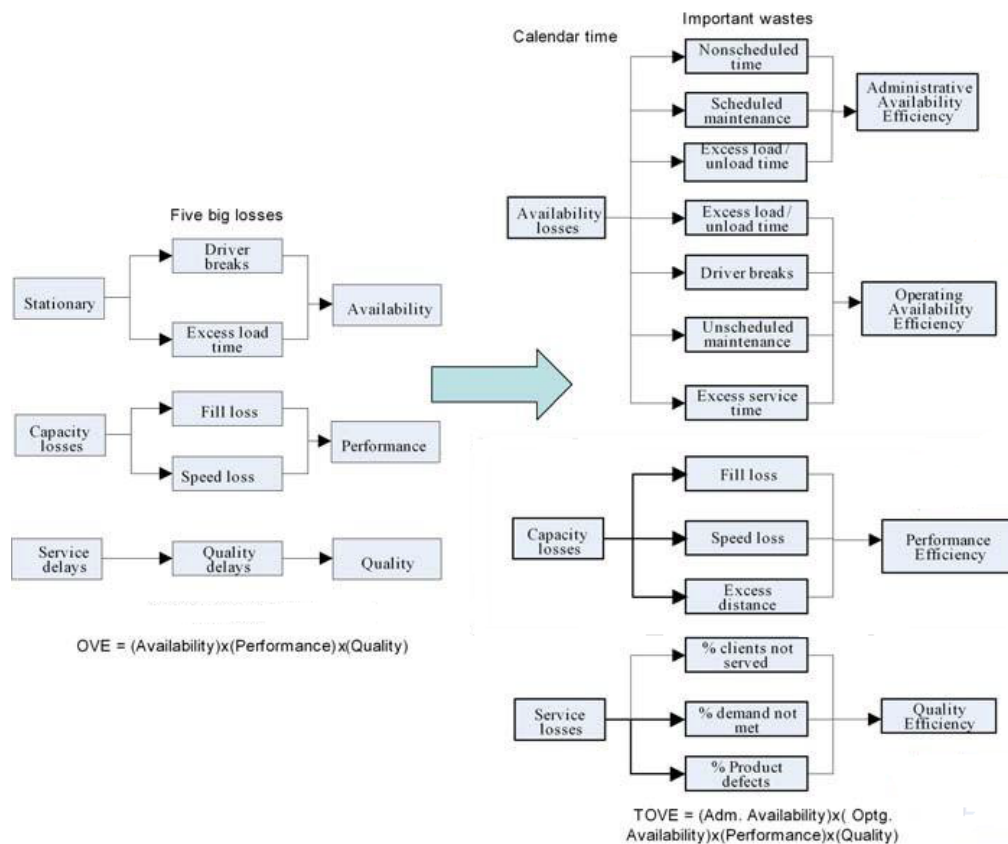

Figure 1 Comparison of the OVE and TOVE structures and components (Adapted from Simmons *et al.*, 2004 and Villarreal, 2012)

The macro context is required to identify the macro characteristics of the route, namely; average journey duration, the current TOVE index level and its components. It is very important to analyze vehicle Administrative Availability utilization based upon calendar time. Identify availability wastes occurring off the route (such as vehicle nonscheduled time and scheduled maintenance time) and the proportion of internal and external activity time. This stage may also serve to guide the improvement efforts according to the values of the TOVE efficiency factors – i.e., Availability, Performance and Quality. At the same time, if all the transport activities are internal there will be an important opportunity to improve vehicle efficiency. The following stage focuses on identifying waste at the micro level. Especially, waste that impact on Performance, Operating Availability and Quality factors. Given the most relevant waste concepts identified, a strategy for their elimination is devised and implemented in the final stage. As previously mentioned, the strategy may consist of initiatives designed with tools and methodologies from the Industrial Engineering and Total Quality Management disciplines and/or the Operations Research area.

3. Implementation and results

The scheme is applied to the distribution operations of one of the leading international steel conglomerates with a Mexican supply chain network. The company is experiencing an important level of transportation cost originated by an important level

of unused truck capacity in its Mexican operations.

Currently, the company requires to transport by truck about half a million tons per year. The firm uses third party transport suppliers. It has agreed with its suppliers a guaranteed freight rate for each delivery without taking into account the weight transported. For example, if the truck has three axles the guarantee rate is the same if the truck delivers up to a maximum of 28 tons. Say, if the load weighs 18 tons, the cost of unused capacity is associated with 10 tons not delivered. In addition, the structure of the rate contains a charge due to the level of waiting time required for loading material in the installation. This charge is estimated in the range of 20 – 25% of the original rate (see Figure 2).
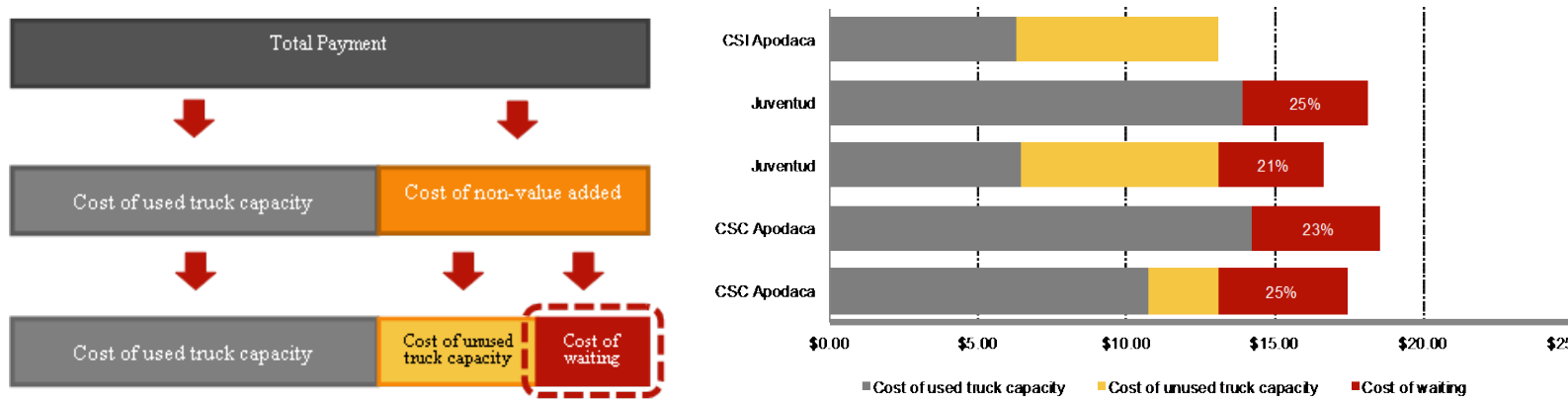

Figure 2 Structure of Freight Rate per Installation

The level of cost of unused truck capacity has been estimated in 75% of the freight during the previous twelve months. For this reason, the company decided to set up a project with the goal of reducing it for its northeastern distributions operations located in metropolitan Monterrey.

3.1 Mapping the transportation process

The first step of the methodology is to map the processes of interest. In this case, the physical activities mapped include from the arrival of the truck to a certain installation to pick-up the required material ordered. After the items are loaded the truck goes through administrative activities before leaving the installation. The truck continues to distribute the products to customers. The current Value Stream Map (VSM) for the logistic operation is shown in Figure 3. The Figure presents a VSM for the Distribution Center operations combined with the TVSM for the distribution operations. The data shown is for the four most important installations in terms of cost of unused truck capacity (CSI Apodaca, Bodega SODISA, CSC Apodaca and Juventud plant).

3.2 Identify relevant wastes

As shown in the map, the two most important wastes found correspond to a Fill Loss of 75% and waiting for loading and loading time in excess of 6 hrs to 8 hrs, depending of the installation where the truck picks up material. The most restrictive operation is picking and loading and Total Value Added Time (VAT) is 20% of total warehousing lead time. Fill loss has an important impact on CUTC through the quantity or volume component of the concept. The waiting for loading and loading time in excess affects CUTC by determining the extra charge of the freight rate for the delivery.
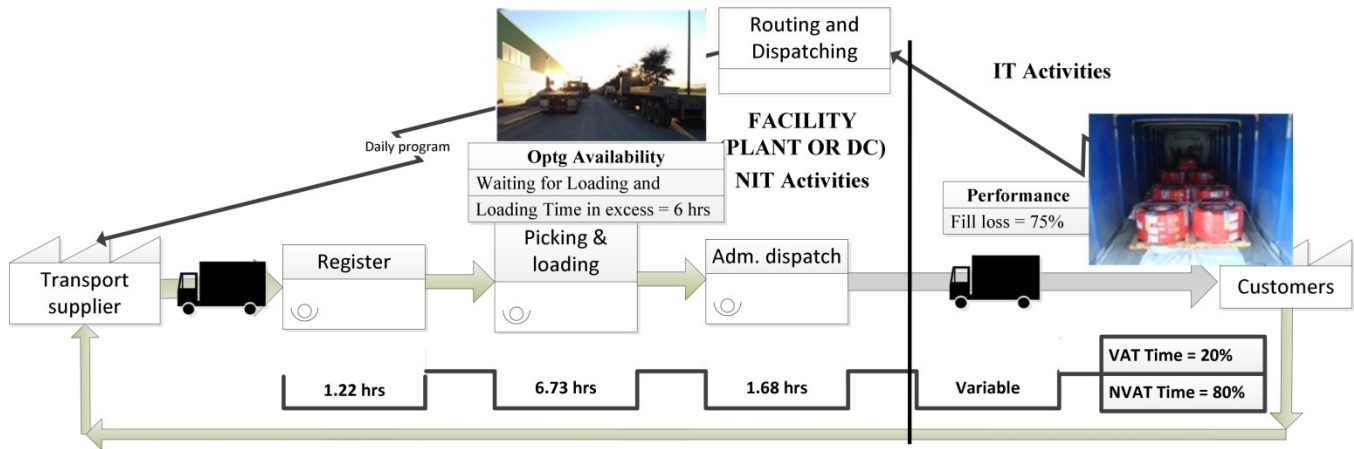
Figure 3 Current TVSM for Ternium´s local transportation operations

3.3 Brief description of improvement initiatives

Table 1 presents a summary of the improvement strategy per type of waste. The recommended projects for reducing Fill Loss or Truck Capacity Under-utilization are: the re-design of trucks to deliver light materials, mix heavy and light materials in a shipment, to consolidate orders from close destinations and to re-organize a transportation management system. For eliminating waiting time for loading and reducing loading time in excess the initiatives considered are the elimination of waste in loading procedures and the re-organization of a transportation management system.

Table 1 Summary of Improvement Strategy

Waste	Cause Description	Initiative
Fill Loss or Under Capacity Utilization	Deficient control of CUTC	Implement standardized control mechanisms
	The shape and weight of product	Re-design trucks to increase load
		Mix heavy and light materials in same shipment
	Lack of product delivery consolidation efforts	Consolidate orders from nearby destinations
	Deficient transportation management.	- Assign different orders to a shipment
Waiting for loading and loading time in excess	Deficient transportation management.	- Enable multi-plant consolidation
		- Schedule truck loading per plant
	deficient loading procedures	Eliminate waste in loading procedures

3.4 Implementation of Improvement Strategy

The implementation of the previously described strategy is under way. This section provides a brief description of the status of this effort for each initiative.

3.4.1 Initiatives for decreasing waiting and loading time in excess

The procedure for loading materials at every installment is important. As identified in Figure 2, the time taken for this activity is significantly large. Further, truck queueing time due to this activity and to the random arrival of trucks, originates long stay times at each facility. After reviewing and analyzing the loading procedures, a siginuificant amount of wasteful movements were found. The activity of searching and moving the material to be loaded at the last minute was the most important. Thus, a new standard procedure was designed that considered the availability of the required material at the dock before the arrival of the chosen truck (see Figure 4). The final loading procedure will include the use of a Drop & Pick scheme. Under this scheme, the transport supplier would leave an empty container at a pre-established location at its entrance to the facility. This container

would be secured with the use of pneumatic devices such as the one illustrated in Figure 4. Then, he will proceed to pick up an already loaded container and leave the facility after satisfying all administrative activities. This scheme will decrease total time at the installation very significantly. This procedure had as a pre-requisite the implementation of a truck schedule for the installation (as shown in Figure 4). This schedule would also be the basis to program the picking and transport activities from the warehouse to the shipping docks.

The implementation of these initiatives is still in progress. The initial step consisted in a pilot test realized in the facility of CSI Apodaca. The results were very impressive and the management of the company decided to continue full implementation into the rest of the operating installations during the second semester of year 2016.

Figure 4 Preparing Material in Advance for Transportation, Device for Enabling Drop & Pick & Scheduling Truck Loading

3.4.2 Initiatives for reducing truck fill loss

The projects defined to decrease the level of truck fill loss had the purpose of consolidating multi-origin, multi-destination and different type of materials per delivery. The company manufactures and distributes a great number of different materials in several plants. These were classified as heavy, intermediate and light for purposes of determining how to transport them in a way that would minimize CUTC. Light materials (e.g. pipes) would never have a zero CUTC. However, heavy materials (e.g. steel coils) would certainly have zero CUTC provided they were ordered. Therefore, the only manner a shipment with light or intermediate materials would have minimum levels of CUTC is to mix them with heavy products. Another requisite that must be satisfied to mix products has to do with their shape. Figure 5 shows the possible combinations of products that can be transported together. Steel coils and stripes can be mixed with all light and intermediate materials. Client orders and the previous matrix served as a guide for defining consolidated transport deliveries.

Client (Distribution Center or Customer) order consolidation is an important initiative to decrease CUTC. The first step was to centralize all customer order and transport supplier information. Then, a broad consolidation scheme was delineated as follows. Heavy materials (coils and stripes) must be considered the anchors around which consolidation is achieved.

Figure 5 Summary of Materiales that can be Mixed and an Example

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The consolidation process starts with the selection of states with a Distribution Center (DC) located in it. Then, all the DC orders and those of the customers located in the state that contain steel coils are identified. Next, full truck load shipments are formed with the coils and other light material ordered. This process continues considering first DC orders and then customer orders until no coils are available. The previous process is repeated, but now the steel coils are substituted by stripes. Finally, the process of consolidation is continued with the rest of the available materials not assigned.

As part of this initiative, several important customers (in terms of their demand volume, order consistency and frequency) were identified. Among these are: Invacare Corporation in Reynosa, Whirlpool International in Ramos Arizpe, Controladora MABE in Celaya, Controladora MABE in Saltillo, and Formex Automotive Industries in Ramos Arizpe. Daily dedicated transportation circuits with consolidated deliveries were designed for them. In some cases, the re-design of platforms or containers were required to accommodate more material as shown in Figure 5. All the previous initiatives have been implemented in pilot projects with very important results. Therefore, the firm has already determined to continue their full implementation throughout the rest of the facilities during year 2016.

3.4.3 Transportation management system
Since most of the initiatives are inter-dependent and require centralized customer, transport supplier and facility information. The firm decided to undertake a company-wide project for automatizing a centralized delivery planning and control system to be designed and implemented in year 2016.

4. Conclusions and results
This work provides a brief description of the application of the efficiency improvement approach to the distribution operations of one of the leading steel Mexican conglomerates. The company is experiencing an important level of transportation cost originated by an important level of unused truck capacity (CUTC). Thus, the management of the company developed a strategy for reducing this cost concept by identifying and eliminating waste in its logistics operations.

The two most important wastes found correspond to a Fill Loss and waiting for loading and loading time in excess. Fill loss has an important impact on CUTC through the quantity or volume component of the concept. The waiting for loading and loading time in excess affects CUTC by determining the extra charge of the freight rate for the delivery. The improvement strategy developed is still in process. Figure 6 describes the behavior of CUTC before and after implementing the strategy. The current level of CUTC is 14 Mexican pesos per ton, 75% lower than the average from Jan – Jun, 2015. It is expected that this level will be at 8 Mexican pesos per ton after full implementation of the strategy.
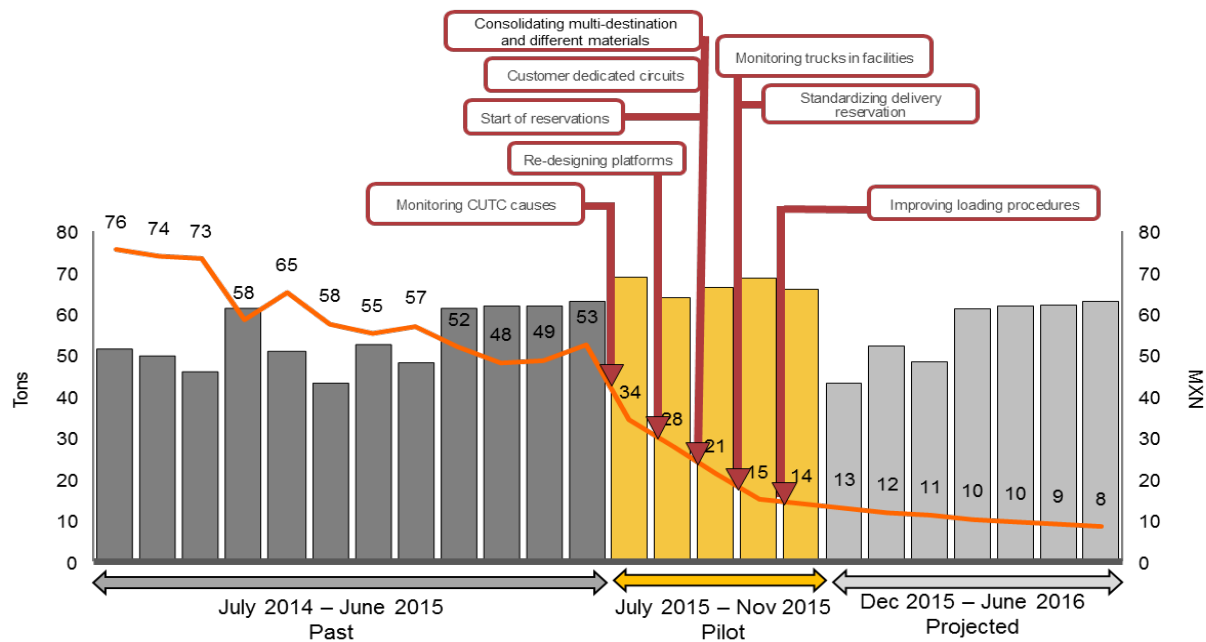

Figure 6 Behaviour of the CUTC Before and After Implementing the Initiatives

References

Bicheno, J. (2004), *The New Lean Toolbox: Towards Fast, Flexible Flow*, 3rd ed., PICSIE Books, Buckingham.

Dennis, P. (2002), *Lean Production Simplified: A Plain Language Guide to the World's Most Powerful Production System*, Productivity Press, New York, NY.

Faulin, J. (2003), "Combining Linear Programming and Heuristics to Solve a Transportation Problem for a Canning Company in Spain", *International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management*, Vol. 6, No. 1-2, pp. 17-27.

Fugate, B.S., Davis-Sramek, B. and 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.

Hines, P., Taylor, D. (2000), *Going lean*, Lean Enterprise Research Centre, Cardiff Business School.

Lam, M., Mittenthal, J. (2013), "Capacitated hierarchical clustering heuristic for multi depot location-routing problems", *International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management*, Vol. 16, No. 5, pp. 433-444.

Mason, R., Simons, D., Gardner, B. (2001), "Translating the overall equipment effectiveness measure from the lean manufacturing paradigm to the road freight transport industry", *Proceedings of the 6th Logistics Research Network Conference*, Edinburgh, September 13-14, pp. 362-367.

McKinnon, A., Campbell J., Leuchars, D. (1999), *Benchmarking vehicle utilisation and energy consumption measurement of key performance indicators*, Energy Consumption Guide 76 (DETR).

McKinnon, A.C., Ge, Y., Leuchars, D. (2003), *Key performance indicators for the food supply chain*, *Transport Energy Benchmarking Guide 78*, Department for Transport, London.

Monden, Y. (1998), *Toyota Production System: an integrated approach to just-in-time*, 2nd ed., Chapman & Hall, London.

Nakajima, S. (1988), *An introduction to TPM*, Productivity Press, Portland, OR.

Ohno, T. (1988), *Toyota Production System: beyond large-scale production*, Productivity Press, Portland, OR.

Pettersen, J. (2009), "Defining lean production: some conceptual and practical issues", *The TQM Journal*, Vol. 21, No. 2 pp. 127-142.

Simmons, D., Mason, R., Gardner, B. (2004), "Overall vehicle effectiveness", *International Journal of Logistics: Research and Applications*, Vol. 7, No. 2, pp. 119-34.

Sternberg, H., Stefansson, G., Westernberg, E., Boije af Gennas, R., Allenstrom, E., Nauska, M.L. (2013), "Applying a Lean Approach to Identify Waste in Motor Carrier Operations", *International Journal of Productivity and Performance Management*, Vol. 62 No. 1, pp. 47-65.

Villarreal, B., Garcia, D., Rosas, I. (2009), "Eliminating transportation waste in food distribution: a case study", *Transportation Journal*, Vol. 48, No. 4, pp. 72-77.

Villarreal, B., Sañudo, M., Vega, A., Macias, S., Garza, E. (2012), "A lean scheme for improving vehicle routing operations", *Proceedings of the 2012 International Conference on Industrial and Operations Management*, Istanbul, Turkey, July 3–6.

Villarreal, B. (2012), "The Transportation Value Stream Map (TVSM)", *European Journal of Industrial Engineering*, Vol. 6, No. 2, pp. 216-233.

Villarreal, B., Macias-Sauza, S., Garza-Varela, E., (2013), "An efficiency improvement approach to reduce transportation cost: an application", *Industrial and Systems Engineering Review*, Vol. 1, No. 2, pp. 153–161.

Womack, J.P., Jones, D.T. (2003), *Lean Thinking – Banish Waste and Create Wealth in Your Corporation*, Free Press, Simon Schuster Inc., New York, NY.

Yu, B., Ma, N., Cai, W., Li, T., Yuan, X. (2013), "Improved ant colony optimisation for the dynamic multi-depot vehicle routing problem", *International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management*, Vol. 16, No. 2, pp. 144-157.

Yu, V.F., Hu, K.J., Chang, A.Y. (2015), "An interactive approach for the multi-objective transportation problem with interval parameters", *International Journal of Production Research*, Vol. 53, No. 4, pp. 1051-1064.

Zhang, R., Yun, W.Y. (2009), "A reactive tabu search algorithm for the multi-depot container truck transportation problem", *Transportation Research Part E: Logistics and Transportation Review*, Vol. 45, No. 6, pp. 904-914.

Biographies

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Jose Arturo Garza-Reyes is a reader in Operations Management and Business Excellence at the Centre for Supply Chain Improvement, Derby Business School, the University of Derby, UK. He has published a number of articles in leading international journals and conferences, including International Journal of Production Research, International Journal of Production Economics, Production Planning & Control, Journal of Cleaner Production, Robotics and Computer Integrated Manufacturing, Journal of Manufacturing Technology Management, International Journal of Quality and Reliability Management, TQM & Business Excellence, International Journal of Productivity and Performance Management, among others. Dr Garza-Reyes has also written two books in the areas of quality management systems and manufacturing performance measurement systems. He has participated as guest editor for special issues in the Supply Chain Management: An International Journal, International Journal of Lean Six Sigma, International Journal of Lean Enterprise Research, International Journal of Engineering Management and Economics and International Journal of Engineering and Technology Innovation. Dr Garza-Reyes is co-founder and current Editor of the International Journal of Supply Chain and Operations Resilience (Inderscience). He is currently serving in the editorial board of several international journals as well as has contributed as member of the scientific and organising committees of several international conferences. His research interests include general aspects of operations and manufacturing management, operations and quality improvement and performance measurement.

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