Improving Distribution Efficiency to Increase Agility: An Application to a Mexican Company

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Abstract

The Lean Manufacturing approach for waste elimination can be applied in all sorts of operations. In this project is applied for the improvement of a supply chain and to achieve high levels of chain efficiency. The identification of warehousing and transportation waste at the chain level is aggregate being difficult its identification within both processes. This work provides an application of the concept of distribution operational efficiency to a Mexican package delivery company that has the need to improve its on-time delivery service. The Operational Effectiveness Index used in TPM is adapted and used as the main performance measure for warehousing and transport operations. Availability, performance and quality wastes are identified using Value Stream Mapping. Results of the application are provided.

Keywords:
Distribution waste elimination; under-utilized truck capacity; value stream map; transportation efficiency; warehousing waste

1. Introduction

As suggested by Christopher (1992), an important feature of business is the fact that competition is made through supply chains and not between the companies. Therefore, it is very important to consider the deployment of the right strategies to compete successfully. Fisher (1997) suggests that supply chains must acquire capabilities to become efficient or agile accordingly to the characteristics of the environment in which they compete. (see Figure 1). In particular, an efficient supply chain is suitable for competing in terms of cost as the winning factor (Hill, 1993). On the other hand, if customer service is the main competitive factor, the supply chain must achieve high levels of agility.

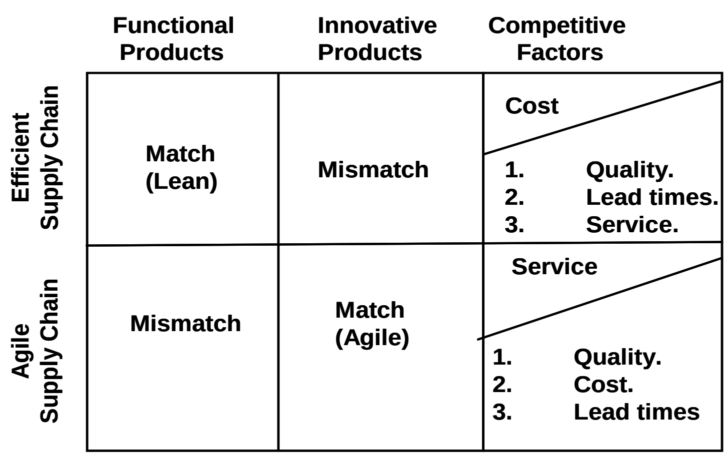

Figure 1 Characteristics of supply chains

The management of lead time can be a competitive advantage as stated Towill (1996). Time based competition refers to the ability to deliver products or services faster than the competitors. Lead time reduction strategies are responses to logistical problems in the areas of procurement, manufacturing and distribution. In particular, an assessment of lead times in distribution systems offers numerous opportunities for improvement as illustrated by Villarreal, et al., (2004). Towill (1996) has stated he idea that time compression (i.e. the collapsing of all cycle times within a supply chain) would enhance business competitiveness to the advantage of all members in the chain. Time compression is a performance driver which initially enhances the competitiveness of individual work processes and then of complete industrial businesses. It has an even greater effect on supply chain competitiveness.

So we conclude that the supply chain process is greatly improved by concentrating on the streamlining of material and information flows, simplifying decision-making procedures and eliminating non - value added activities. The concept of agility is related to the capacity of responding to market needs and changes. The concept of decoupling point (DP) defined by Hoekstra et al., (1992) is relevant for the previous strategy making process. This point corresponds to the farthest upstream position in the supply chain where the customer order is satisfied. As suggested by Christopher et al., (2001) and Masson-Jones et al., (2000), this point is used to structure a leagile (lean and agile) strategy for the supply chain. After identifying the DP position, a lean strategy is recommended for the part of the chain located upstream this point. Similarly, an agile strategy is suggested for the part located downstream the point. In fact, lean methodologies are important contributors to the creation of agile systems as stated by Christopher et al., (2001). The idea that lean precedes agile is established.

This work presents a scheme with the purpose of improving agility of a Mexican firm by reducing waste in physical distribution to increase efficiency. It is suggested to begin the waste elimination strategy with the definition of an extended operational efficiency measure, similar to the one recommended by Nakajima (1988). This paper consists of five sections. Sections one and two are brief reviews of the literature on lean distribution. Section 3 introduces the concept of distribution efficiency making the Operational Equipment Effectiveness (OEE) the base measure. Section 4 presents a structure for the value stream mapping. Section 5 gives a description of the scheme utilized to decrease waste. The application of this scheme is undertaken in section 6 and section 7 presents conclusions.

2. Review of distribution efficiency literature

As it was previously established, the increase of distribution efficiency is achieved through the elimination of waste. This process is guided by efficiency measures for transportation and warehousing. These measures are derived from the principles of Operational Equipment Effectiveness (OEE) used to measure the effective utilization of resources in manufacturing operations, Nakajima (1988). But, as Scott et al., (1998) have pointed out; the gains in OEE are not enough because machines are not isolated. This insufficiency of the OEE measure has led to modifications to fit a broader perspective in the manufacturing systems. For instance, Huang, et al., (2003) suggest the use of the Overall Throughput Effectiveness (OTE) to estimate effectiveness at factory level and Muchiri, et al., (2007) propose the Overall Asset Effectiveness (OAE) that is used to identify the losses occurring in the overall production process and a framework for measuring production losses. This framework considers three levels of effectiveness measurement, the equipment level effectiveness (based on OEE), the operational level effectiveness using the Total Equipment Effectiveness Performance to include maintenance downtime and the business level effectiveness measured by the (OAE/OPE). The framework was further extended one more level upwards to incorporate the supply chain by Villarreal, et al., (2012). At this level, the OAE has to be adapted to consider not only manufacturing plants; but distribution installations such as warehouses and cross-docking points and transportation assets such as trucks and railroad equipment.

Transport efficiency was originally suggested by Simmons et al., (2004). They made the measurement with the Overall Vehicle Effectiveness (OVE). Similar to the estimation of OEE, were calculated the availability, performance and quality efficiency factors and multiplied to produce an overall OVE percentage rate. This measure converted the OEE losses from manufacturing to transport operations. The result was the definition of five transport losses or wastes. These are driver breaks, excess load time, fill loss, speed loss and quality delays. The previous measure has also been modified by Villarreal (2012). In this case, the OVE measure is adapted to consider total calendar time as suggested by Jeong et al., (2001). This is due to the fact that waste identification and elimination is related to the transportation vehicles utilized to move product. Figure 2 illustrates the concepts and losses involved in the proposed measure that is called Total Operational Vehicle Effectiveness and represented by the term TOVE. In summary, four components for the new efficiency measure are suggested; Administrative or strategic availability, operating availability, performance and quality. The new measure would be obtained from the product of administrative availability, operating availability, performance and quality efficiency factors. In addition to the types of waste given by Simmons, et al., (2004), Villarreal (2012) suggest the additional types of waste shown in Figure 2.

The OEE measure is also adapted to analyze warehousing operations by Villarreal, et al., (2012). The measure (represented as WOEE) considers total calendar time instead of loading time. Furthermore, since the interest is put on the warehouse efficiency as a system, it is also suggested a measurement based on the bottleneck or most constrained operation of the facility, similarly to the Overall Throughput Effectiveness (OTE) measure developed by Huang, et al., (2003). Thus, improvement efforts will be focused on the warehouse bottleneck resource using a scheme based on Theory of Constraints. Figure 1 illustrates the concepts and losses involved in the proposed measure. In summary, similar to the definition of the TOVE measure, four components for the new efficiency measurement are suggested, being them administrative or strategic availability, operating availability, performance and quality. Waste identification is supported by the elaboration of a Value Stream Map (WVSM) for all warehousing operations including specific efficiency information for the bottleneck resource. Waste identification is supported by the use of a Value Stream Map.

It is suggested the elaboration of the two-level value stream map; a supply chain level map and an installation (plant, warehouse, route, etc.) level map. The high level VSM is intended to identify strategic waste and provide overall guidance for waste elimination at the tactical and operational levels. Jones, et. al., (2003) suggested the extended VSM to include the supply chain as a system. Such VSM is considered with the addition of information on the efficiency measures for the facilities or installations that form the chain. Every plant, warehouse or transportation route includes its corresponding OAE, WOEE and TOVE. At this level, the VSM focuses on product flow. The next VSM level is detailed and provides the required information for identifying waste at the facilities.

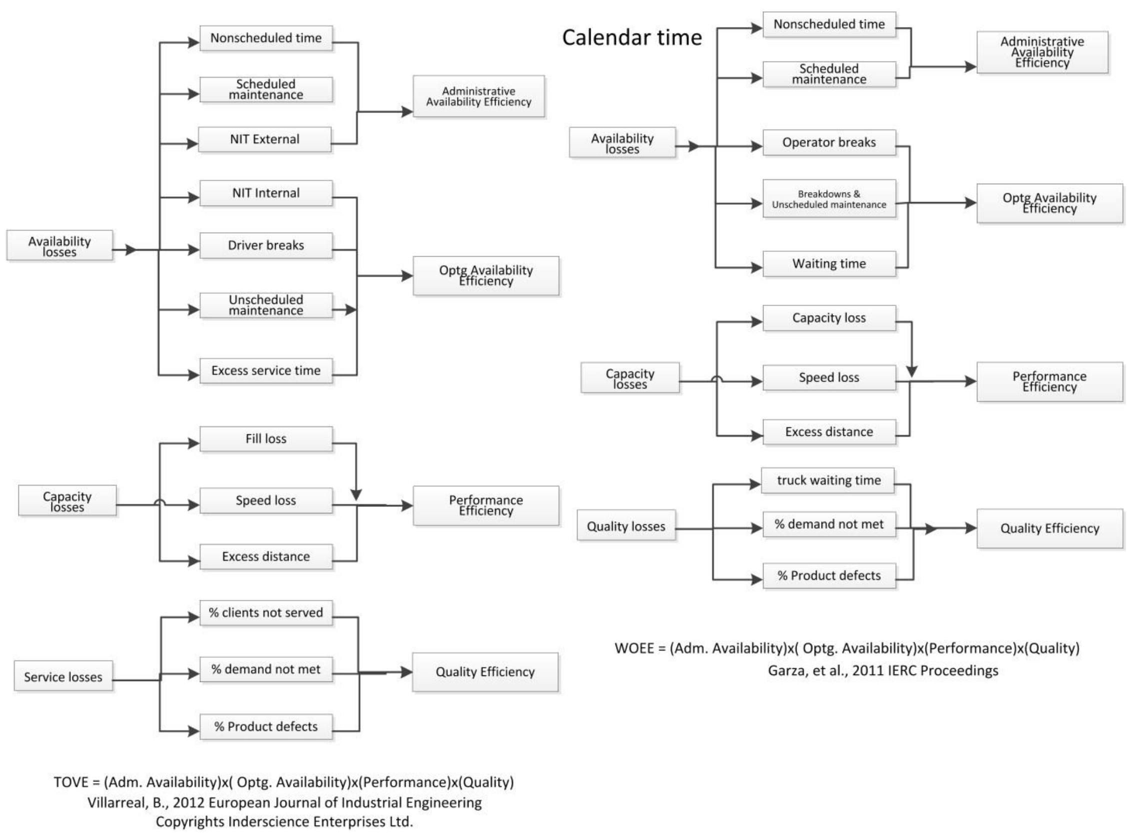

Figure 2 Description of TOVE and WOEE measures

The VSM suggested for transportation is based upon the work of Villarreal, et al., (2012). This map focuses on identifying and reducing the waste related to the flow of transportation vehicles. The metrics to be used to assess are performance and vehicle availability and performance and route quality. Finally, the wastes associated with each metric are identified for elimination purposes. The VSM considered for warehousing is suggested by Villarreal, et al., (2012). This tool includes the description of several types of warehousing waste related to improving efficiency as the relevant performance measure in operations. Figure 2 illustrates the concepts and losses involved in the proposed measure. In summary, four components for the new efficiency measure are suggested; Administrative or strategic availability, operating availability, performance and quality.

3. Description of the waste reduction scheme

This work considers a two-stage, top-down scheme to guide waste elimination projects for improving distribution efficiency (Villarreal et al., 2012). The scheme consists of four general stages: The first stage begins with the alignment of the company strategy to the project. The nature of the resulting strategy depends on the competitive factors identified in this stage. The waste identification phase is enriched with the use of value stream mapping. There are two levels for waste identification; at chain level and at each facility and/or route level. This phase should be exhaustive to set a strong foundation for an effective strategy for waste elimination.

The third phase consists on the determination of waste elimination strategies at the chain and installation levels. Inventory reduction strategies as well as the strategies for transportation distribution scheme, facility relocation and transportation mode change could be used to eliminate waste at the chain level. Waste elimination at the installation level is focused on the definition of strategies to increase availability, performance and quality efficiencies at selected installations of the chain. It is suggested to sequence the efforts beginning with wastes at the chain level.

4. Implementation and results

The scheme is applied to the distribution operations of a Mexican package delivery firm to improve its on-time delivery level. This is based on the application of a transportation waste elimination approach on its routing operations on a detailed level. The company has an extended national network with an important private fleet. The current level of on-time delivery is estimated on 75% on average which is considered as poor by the management.

The Project for increasing the level of customer service was divided into two stages; The initial step consists of analyzing and defining an improvement strategy for the operations serving the Monterrey metropolitan area. This operation serves 30% of the national market of the company and it is the area with 41% of the services delivered after the promised date. The next and final stage would consist of extending the analysis approach to the rest of the national operations. The system of interest is described in Figure 3.

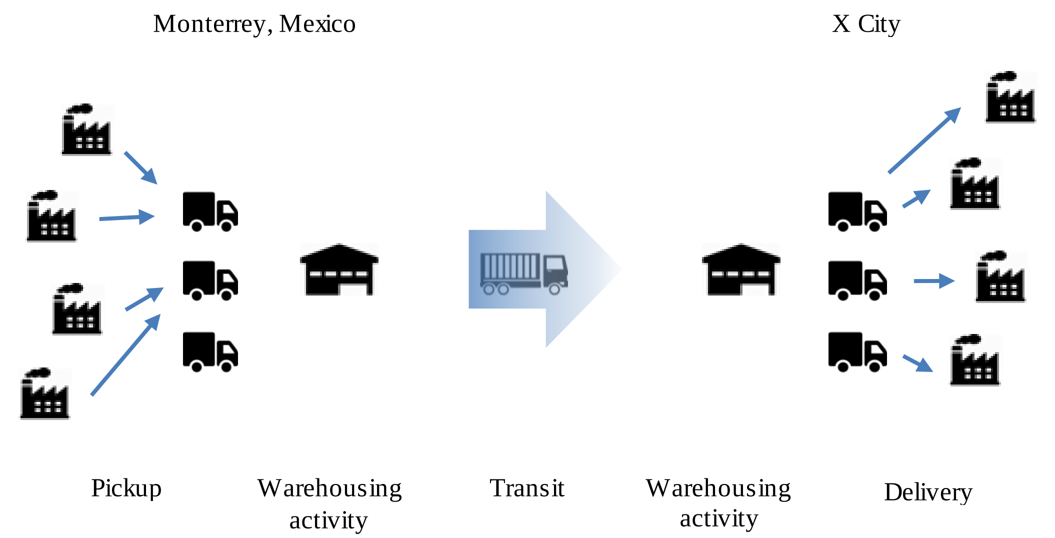

Figure 3 Description of supply chain system of interest

Product deliveries originate throughout every city of the country with a destination to Monterrey metropolitan area. All of these deliveries are consolidated at each city and sent to the Distribution Center located in Monterrey. These are then unloaded and sorted according to the different routes in charge of distributing them to the end customer. Once the fleet finishes delivering items to the clients, it starts the collection process of items that will be sent to other cities of the country. After an exhaustive analysis of the deliveries made during the last twelve months, it was found that 93% of the late deliveries to the customers was due to the Monterrey metropolitan operations.

4.1. Mapping the distribution process of interest

The first step of the methodology is the mapping of the operations. In this case, a VSM for the distribution process of interest at the supply chain level is elaborated. As described earlier in the previous section, the company is concerned with improving the customer service level for the Monterrey metropolitan operations. Therefore, mapping the inbound transport to the Monterrey Distribution Center (DC), the warehousing activities of the DC and the outbound transport to the customers is of interest.

Figure 4 illustrates a two-level VSM of the Monterrey metro area operations. This VSM presents a description of the distribution operations of interest at the supply chain level and at the operational level of each installation. The warehousing efficiency is estimated after the identification of the bottleneck operation, which in this case is the unloading and putaway activities. Therefore, the warehousing efficiency, to be represented by WOEE hereafter, is estimated in 6.4%. The efficiency of the transport operations is measured utilizing the TOVE measure suggested by Villarreal (2012). Its value is 7.6%. Considering the efficiency values for the Distribution Center and of the transport operations, the Management of the firm decided to implement the improvement efforts at the DC first.

An initial study of the causes for the low level of on-time deliveries yielded that; 98% of the inbound deliveries arrived on time to the DC, according to the program previously defined; the activities of the DC and the routing operations were the main contributors to the low customer level.

The DC activities were not capable of feeding the routing fleet with the daily deliveries on time. For this reason, there was a 8% of them that stayed in the DC every day. In addition, for those that were sent out to the customers, there was also a 7% that returned to the DC because of lack of time to distribute them.

4.2 Improving warehousing performance

As shown in the detailed WVSM presented in Figure 4, the most restrictive activity of the DC is unloading and putaway of the incoming trucks from the rest of the Mexican cities to the DC. This was due to the limited unloading capacity resulting from having only one operator and the condition in which the product was delivered. As shown in Figure 5 this was not properly located in the truck and it was unwrapped.

Figure 5 Product sent from rest of Mexican cities

The administrative availability of this working station is estimated in 75% because it is open from 6:00 A.M. until midnight. However, only four hours per day are assigned for unloading deliveries incoming from the rest of the Mexican cities. About 42% of the daily load arrives from 6:00 to 8:30 A.M., and the rest arrives until 10:00 A.M. It has been found that 56% of this available time is classified as non-value-added. Therefore, the operating availability is estimated in 9.7%. The quality efficiency factor depends on the number of deliveries not sent to the customers. This is estimated on 89%. The estimated value of the efficiency of this work station is 6.4%.

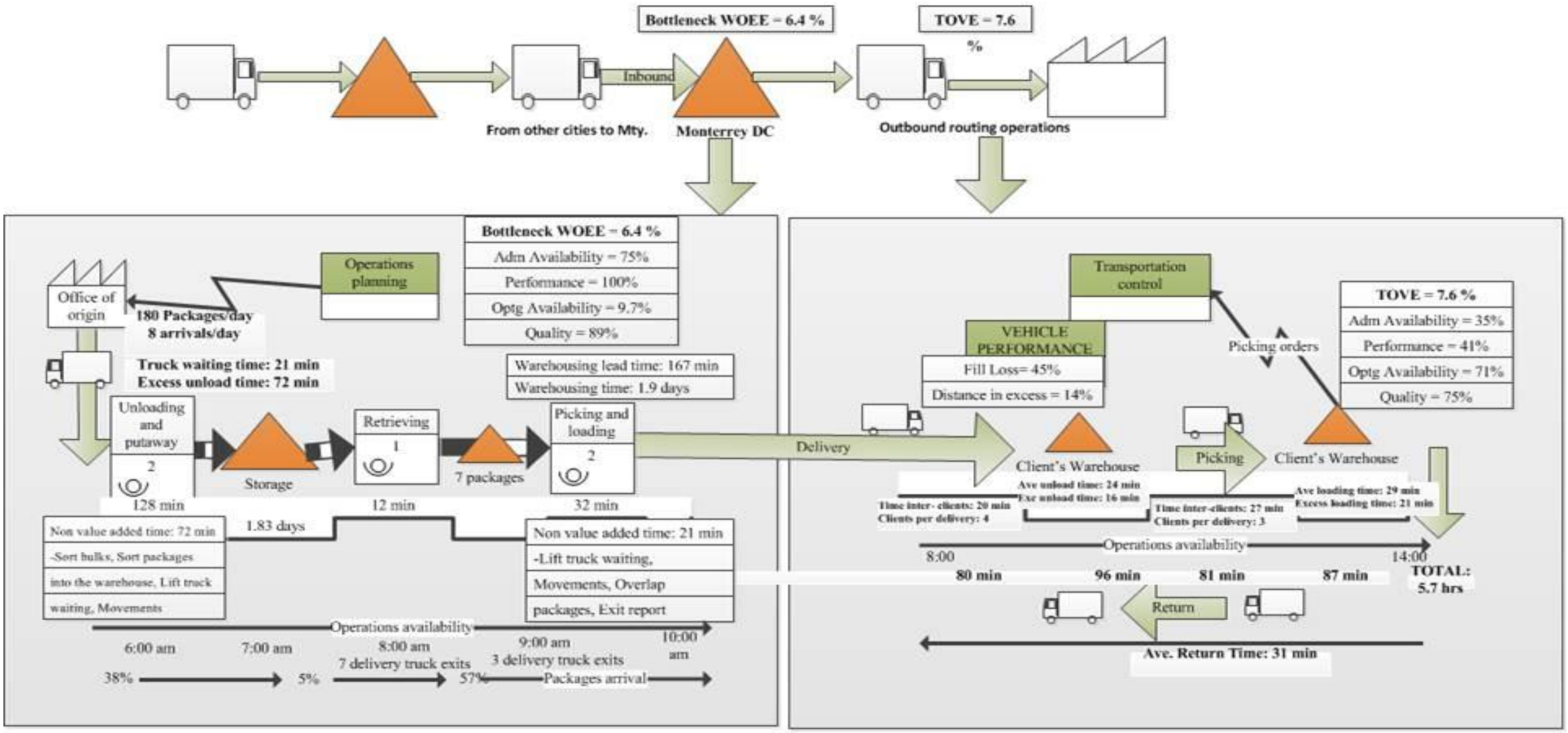

Figure 4 Supply chain level VSM of distribution operation

Defining the improvement strategy

The first initiatives required to implement are associated to increase the operating availability factor and the unloading capacity. Two actions were taken; the first was to require that all the DC´s of the Mexican supply chain needed to wrap all the products delivered to customers (see Figure 6). A complementary action taken was to load the trucks in such a way to facilitate the unloading process at their destination by customer and route. The second action considered consisted on re-assigning another operator from other work station to the unloading station.

Additional initiatives were included to insure a smoother flow of the product throughout the DC. The layout of the DC was redesigned to facilitate the put away, picking and loading activities. Additional loading docks were included in the new design to permit simultaneous route loading.

4.3 Improving the transportation process

The Transportation Value Stream Map for the current routing (distribution and collection) operations is shown in Figure 4. Total Not-In-Transit (NIT) activities take 63 minutos per journey. In-Transit (IT) activities consist of delivering items to an average of four customers per route and collecting items from an average of three customers per route. Total transit time is 5.7 hrs.

Figure 6 Example of wrapped product

4.3.1 Identification of route efficiency and main wastes

The value of the average route efficiency is given by the TOVE value of 7.6%. The Performance and Administrative Availability efficiencies are the factors with the biggest area for improvement with 41% and 35% respectively. However, the company was very concerned with the current level of non-satisfied customers. About 25% of the deliveries are late, including that 7% of the total deliveries, per route, are being returned to the DC every day. The company experienced that an important level of customers did not returned for business after having such a customer service level. As a result, the company decided to undertake an improvement effort to reduce significantly the level of late deliveries. After an exhaustive field work, the following causes for being late were identified; There was not enough time to service the customers because it was necessary to collect new deliveries for others destinations, damaged merchandise and administrative mistakes. Therefore, it was necessary to delineate an improvement strategy to attack the previous causes.

The most important wastes that impact the Performance efficiency are the Fill Loss of 45% and the distance traveled in excess of 14%. Figure 7 illustrates an example of the fill loss waste and it also shows how routes overlap presenting symptons of deficient route design.

	Unidad	Zona asignada		Unidad	Zona Asignada
	507	Comodín		520	Centro
	508	Guadalupe		522	Santa Catarina/SP/García
	512	San Nicolás/Escobedo		524	Monterrey (Poniente)
	518	García		525	Comodín
	519	Apodaca		1027	Santa Catarina/García

Figure 7 Illustration of fill loss and deficient route design

As previously stated, the low level of customer service is due to insuficient time for delivering items to customers. Therefore, a strategy based on reducing time by improving the Performance efficiency to then use it to serve customers is delineated.

4.3.2 Defining improvement strategy

The strategy for improving performance consists of three initiatives: the first one is the assignment of the trucking capacity throughout the day. The second initiative is the application of a route design tool to define everyday the required routes necessary to satisfy customer demand. Finally, several administrative actions were defined and implemented to avoid the administrative mistakes that originated the return of certain item deliveries.

The initial step consisted of modifying the truck assignment schedule throughout the day adjusting it according to the trucking capacity requirements. The current private fleet of the company assigned to the Monterrey metropolitan operations consisted of fifteen 10-ton trucks. The second step for improving performance consisted of using a route design software. First, the current customer database was updated. Then, a pilot test for 30% of the fleet was carried out during two weeks. Daily route design was carried out to satisfy customer delivery demand. This activity was done twice per day; the first one considered the arrival of items from all the Mexican cities but Guadalajara and México, D.F. This run also included item pickups already programmed from the day before. The second route design run was executed to design delivery services for the items coming from Guadalajara and México (see Figure 8 for an example).

The initial results obtained from the pilot work were very promising. The company decided to apply the routing tool to design all the daily delivery routes. In addition to the implementation of the new daily truck assignment schedule and the route design tool, the company redefined its organization, designed a checking list and a motivation campaign to insure that the new procedures are followed.

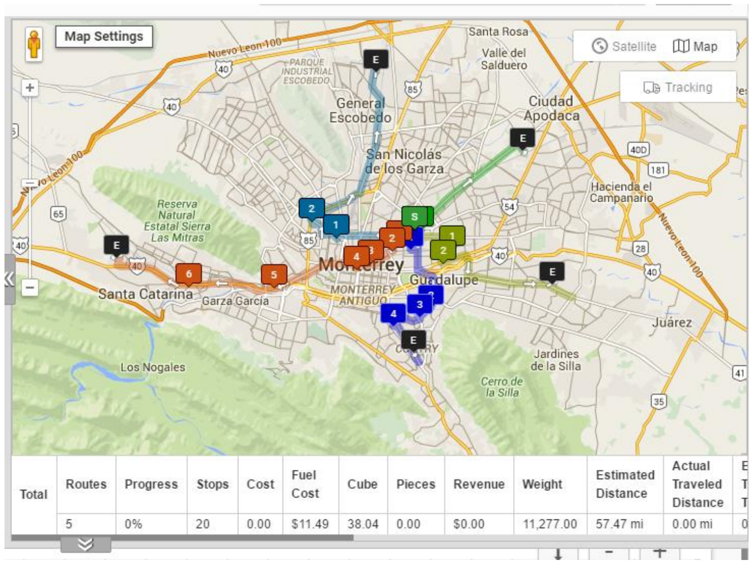

Figure 8 Description of route design

4.3.3 Description of Results

The results obtained from the application of the improvement strategy were very important. The number of deliveries not sent to the customers decreased to zero after implementing the wrapping activity, adding a new operator in the unloading station and redesigning the DC layout (see Figure 9). Similarly, after improving the routing operations, the number of deliveries returned to the DC was reduced to zero as presented in Figure 10. As shown in Figure 11, the On-Time delivery concept was increased from 74% to 100%.

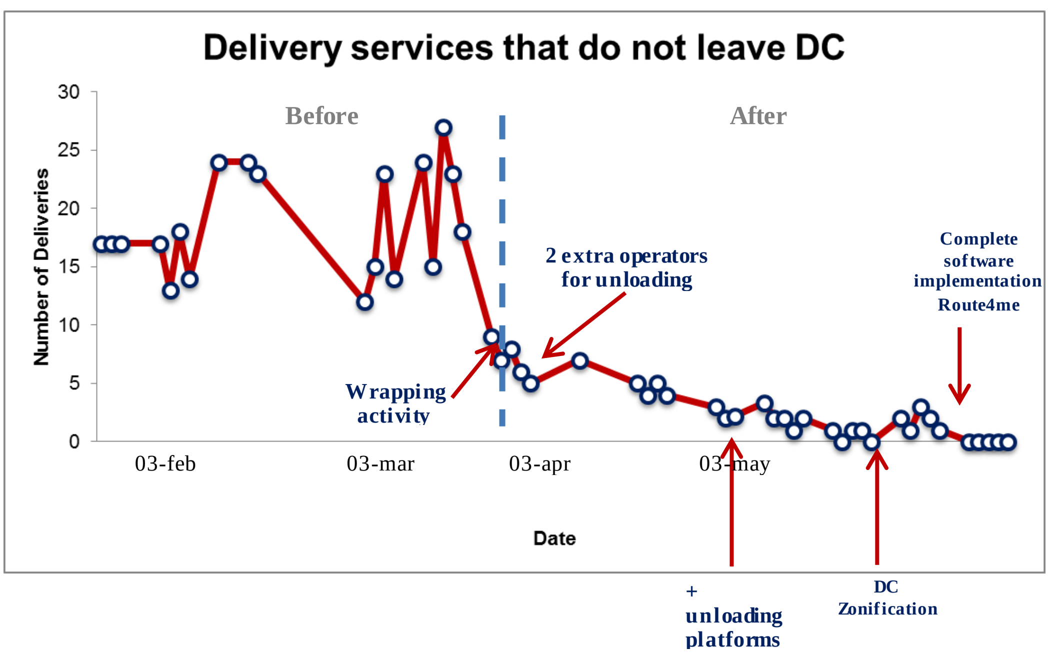

Figure 9 Behavior of the number of daily delivery services staying in the DC

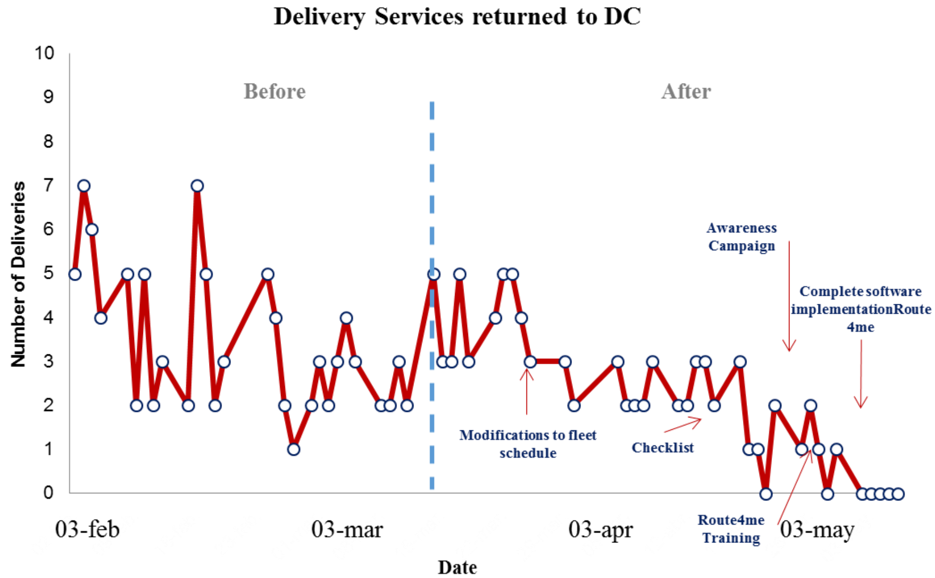

Figure 10 Behavior of the number of daily delivery services returned to the DC

Finally, As shown in Figure 11, the On-Time delivery concept was increased from 74% to 100%, after implementing the improvement strategy.

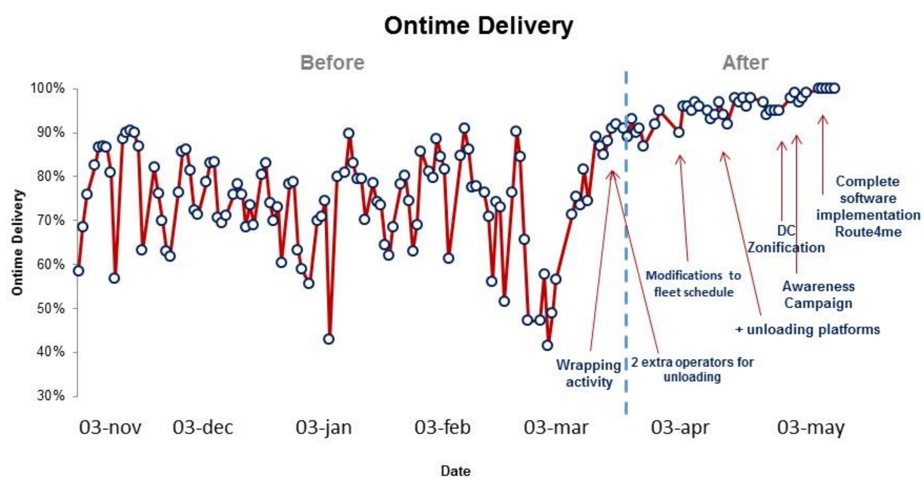

Figure 11 Description of the impact of improvement strategies

Table 1 presents a summary of additional results achieved with the implementation of the previous initiatives. Distance per route decreased 31%, the number of clients visited per route increased from 29% and the utilization of truck capacity increased from 55% to 79%. The cost per delivery decreased from 35.1 to 16.1 Mexican pesos (1.90 to 0.87 US dls per delivery).

Table 1 Summary of Results with New Initiatives

Concept	**Initial Situation**	**New Situation**
Distance/Route (kms)	39.2	27.1
Clients/Route	7	9
Journey Time (minutes)	342	167
% Fill Loss	45	21
MXN Pesos/Delivery	35.10	16.06

5. Conclusions

This work describes the strategy of a Mexican package delivery firm to improve its agility measured in terms of the on-time delivery level. This was achieved based on the application of a transportation waste elimination approach on its routing operations on a detailed level. The initial level of on-time delivery estimated in 74% on average was increased to 100%. Based on the previous results, the firm decided to spread the implementation of the initiatives to the national level during the rest of year 2016. In addition, the logistics operations management of the company had a very positive reception of the lean approach taken to improve the performance.

References

Christopher, M., *Logistics & Supply Chain Management*, 1st edition, London, Pitmans, 1992.

Christopher, M. and Towill, D., An Integrated Model for the Design of Agile Supply Chains, *International Journal of Physical Distribution & Logistics Management*, Vol. 31, No. 4, 2001.

Fisher, M.L., What is the right supply chain for your product?, *Harvard Business Review*, 1997.

Garza, F., Lopez, N. and Guerra, C., Eliminating Warehousing Waste: An Application, 2011 IERC Proceedings, Reno, Nevada, 2011.

Hill, T., *Manufacturing Strategy: Text and Cases*, 2nd ed. (London, Macmillan), 1993.

Hoekstra, S., & Romme, J., *Integrated logistics structures: Developing customer oriented goods flow*. London: McGraw-Hill, 1992.

Huang, S.H., Dismukes, J.P. Shi, J., Su, Q., Razzak, M.A., Bodhale, R. and Robinson, D.E., Manufacturing Productivity Improvement Using Effectiveness Metrics and Simulation Analysis, *International Journal of Production Research*, Vol. 41, No. 3, 2003.

Jeong, K. and Phillips, D.T., Operational Efficiency and Effectiveness Measurement, *International Journal of Operations and Production Management*, Vol. 21, No. 11, pp 1404-1416, 2001.

Jones, D. and Womack, J., *Seeing the Whole*, Productivity Press, 2003.

Mason-Jones, R., Naylor, B., & Towill, D. R., Engineering the leagile supply chain, .*International Journal of Agile Management Systems*, 2(1), 54–61, 2000.

Muchiri, P. & Pintelon, L., Performance Measurement Using Overall Equipment Effectiveness (OEE): Literature Review and Practical Application Discussion, *International Journal of Production Research*, Vol. 46, No. 13, pp. 3517 – 3535, 2007.

Nakajima, S., *Introduction to Total Productive Maintenance (TPM)*, Productivity Press: Cambridge, MA, 1988.

Scott D. and Pisa R., Can Overall Factory Effectiveness Prolong Moore's Law?, *Solid State Technology*, Vol 41, No 3, 1998.

Simmons, D., Mason, R. and Gardner, B., Overall Vehicle Effectiveness, *International journal of Logistics: Research and Applications*, Vol. 7, No. 2, pp. 119-34, 2004.

Towill, D.R., Time compression and supply chain management – a guided tour, *Logistics Information Management*, Vol. 9, No. 5, 1996.

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

Villarreal, B., Elizondo, G., Rocha, A. & Villarreal, A., Achieving Agility Through Postponement: An Application, Proceedings of the Second World Conference on POM, Cancun, MX, 2004.

Villareal, B., Garza, F., Rosas, I. and Garcia, D., An Introduction to Distribution Operational Efficiency, *International Journal of Industrial Engineering*, Vol. 19, No. 7, pp. 278-288, 2012.

Biographies

Bernardo Villarreal is a full professor of the Department of Engineering of the Universidad de Monterrey. He holds a PhD and an MSc of Industrial Engineering from SUNY at Buffalo. He has 20 years of professional experience in strategic planning in several Mexican companies. He has taught for 20 years courses on industrial engineering and logistics in the Universidad de Monterrey, ITESM and Universidad Autónoma de Nuevo León. He has made several publications in journals such as Mathematical Programming, JOTA, JMMA, European Journal of Industrial Engineering, International Journal of Industrial Engineering, Production Planning and Control, International Journal of Logistics Research and Applications, Industrial Management and Data Systems and the Transportation Journal. He is currently a member of the IIE, INFORMS, POMS and the Council of Logistics Management.

Ilse-Valeria Benavides-Peña is a SUMA CUM LAUDE Industrial Engineer just graduated from Universidad de Monterrey (UDEM). She has participated on several projects such as the Improvement of the routing operations of a soft drink bottling firm. She also applied Lean Thinking principles for Improving the Productivity of several assembly lines for a Mexican toy company. Nowadays, she has started graduate work for a master degree in management at UDEM. Ilse is a member of the IIE, ASQ and APICS Societies.

Valeria Garza-Amaya is a CUM LAUDE Industrial Engineer just graduated from Universidad de Monterrey (UDEM). She has participated on several projects such as the Improvement of the routing operations of a soft drink bottling firm. She also applied Lean Thinking principles for Improving the Productivity of several assembly lines for a Mexican toy company. Currently, she has started to work at a Mexican firm leader in the manufacturing of frozen and refrigerated food as an operations improvement analyst. Valeria is a member of the IIE and ASQ Societies.

Cecilia Garza-Madero is a CUM LAUDE Industrial Engineer just graduated from Universidad de Monterrey (UDEM). She has participated on several projects such as the Improvement of the routing operations of a soft drink bottling firm. She also applied Lean Thinking principles for Improving the Productivity of several assembly lines for a Mexican subsidiary of GE. At the moment, she initiated working as a production programmer in a Mexican integrated steel company. Cecilia is a member of the IIE, ASQ and APICS Societies.