Routing Lean and Green in UPS

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Abstract

This work describes the strategies of UPS Mexico to decrease transportation costs and improve the level of sustainability on its routing operations located in the metropolitan area of Monterrey, Mexico. This is based on the identification of efficiency and selected environmental wastes using a modified Transportation Value Stream Map. The reduction of cost is based on the application of a scheme for improving efficiency based on an index adapted from the Operational Equipment Effectiveness index used in TPM. Availability, Performance and Quality wastes are identified. A scheme to devise a combined strategy to decrease both efficiency and environmental wastes is described. The implementation of the improvement initiatives is still in progress but projected and available results are provided.

Keywords
Transportation waste elimination, environmental wastes, value stream map, transportation efficiency, vehicle routing problem

1. Introduction

A key feature of present-day business is the idea that it is supply chains that compete, not companies (Christopher 1992). It is extremely important that firms undertake the right strategies to compete successfully. According to Fisher (1997), supply chains must acquire capabilities to become efficient or agile in accordance with the type of products they market. In particular, an efficient supply chain is suitable for selling functional products. The main supply chain strategy recommended by Towill, et al. (2002) to become efficient is waste elimination.

The problem of concern in this paper is twofold: the reduction of transportation cost and the improvement of sustainability in routing operations. The reduction of routing costs has been treated exhaustively in the academic literature. The Vehicle Routing Problem is well known in the Operations Research and Just in Time literature. Its application is well suited to situations in which full truck loads are not possible, and the consolidation of orders or loads from several points are required to achieve higher capacity utilization levels for reducing transportation cost. From the O.R. point of view, the interest is concentrated on the development of algorithms to achieve an optimal or near-optimal solution to the problem. From the JIT literature, Vehicle routing is a key aspect to enable frequent shipments of small lots from suppliers to customers, and therefore allowing for a Just in Time integration with them. This work provides a description of the application of an approach that integrate both views; O.R. and JIT to the routing operations of UPS located in Monterrey, Mexico. This scheme has the purpose of identifying and reducing waste in this activity and is discussed in detail in Villarreal (2012) and Macia-Sauza, et al. (2012).

However, the implementation of lean principles without the consideration of its impact on environmental performance could have negative results. In particular, if these efforts are in the area of transportation. According to the U.S. Department of Energy transportation, the U.S. contributed with more than two billion metric tons of CO2 emissions in 2007. As illustrated by Venkat, et al. (2006), lean supply chains can produce higher CO2 emissions, especially when there are long distances between facilities. The US Environmental Protection Agency recommends the integration and implementation of a lean and environmental improvement strategy (US EPA 2007). However, this suggestion has not been fully implemented. A survey described by Golicic, et al. (2010) finds that fewer than 10% of Fortune 500 companies have addressed the environmental impacts of transportation, and even fewer are actively implementing improvements.

In view of the previous considerations, the project undertaken by UPS, México is among the first attempts to discuss the combined problem of efficiency and environmental waste reduction. This report consists of five sections. The next section deals with a brief review of the literature on the Vehicle Routing Problem (VRP), lean
and green 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 vehicle routing problem (VRP) is one of the most studied among the combinatorial optimization problems, due both to its practical relevance and to its considerable difficulty. The VRP is concerned with the determination of the optimal routes used by a fleet of vehicles, based at one or more depots, to serve a set of customers. The objective considered could be the minimization of distance, time or cost. In certain sense, the purpose would be to eliminate excess distances or time which are considered as wastes in the lean thinking arena. Several surveys of the different algorithms developed to solve the VRP problem with various characteristics and assumptions are available in the literature (Golden 1997).

Figure 1: Structure of TOVE Measure

Lean is the relentless elimination of waste in every area of operations. 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 manufacturing techniques over the last 50 years has come from Japanese automotive manufacturer, Toyota. Taiichi Ohno defined seven common forms of waste: production of goods not yet ordered; waiting; rectification of mistakes; excess processing; excess movement; excess transport; and excess stock.

The Lean approach to enable waste elimination throughout the supply chain was extended in Womack, et al. (1994). Transportation is one area where the application of lean techniques would yield important benefits. It is well known that transportation is an activity classified by the lean movement as waste. However, in a world where markets are distant, it becomes a necessary activity to move goods to each customer.

The literature research on the development of concepts, methodologies and applications of lean thinking in the transportation sector is rather limited. Most of the existing work concentrates on the definition of wastes specific to this process (McKinnon, et al. 2003 and Simons, et al. 2004). A new measure called Overall Vehicle Effectiveness, OVE, to be used for improving the performance of truck transportation is provided by Simons, et al. (2004). This is an extended version of the Overall Equipment Effectiveness indicator employed in lean manufacturing to improve
equipment efficiency. A modified version of the OVE measure is suggested by Villarreal (2012). This is called TOVE and considers total calendar time instead of loading time. As illustrated in Figure No. 1, four components for the new efficiency measure are suggested: Administrative or Strategic Availability, Operating Availability, Performance and Quality efficiencies. The new measure, TOVE, would be obtained from the product of the efficiencies mentioned above. There are several waste concepts associated with each efficiency factor. For example, fill loss, speed loss and excess distance travelled are wastes that impact performance efficiency. Wastes related to quality efficiency are percentage of demand not satisfied or product defects originated by mishandling during transportation. Driver breaks, breakdowns, corrective maintenance, and customer excess service time affect operating availability efficiency. The concept of vehicle administrative availability is important because it has a significant impact on the overall vehicle utilization and efficiency. It is mainly the result of administrative policies and strategies related to capacity or maintenance decisions. The main waste associated with this concept is nonscheduled time. A value stream map for transportation processes (TVSM) that concentrates on identifying waste related to transport efficiency is provided by Villarreal (2012).

In summary, improving routing efficiency has been mainly sought by operations researchers through the development of algorithms that look for the achievement of “zero travelling distance or time wastes”. However, it has been found that this is not the only important concept of waste occurring in this activity. Waste related to low availability factor values has been found to be very significant by McKinnon, et al. (2003), Molina, et al., (2012) and Simons, et al., (2004).

According to the US EPA (2007), an environmental waste is any unnecessary use of resources, or substance released to the air, water or land that could harm human health or the environment. Within the developed world there are four basic transport modes for shipping large quantities of packaged products: water, rail, truck, and air. Trucking dominates, comprising more than 75% of the total Mexican and U.S. freight transit bill. The transportation sector is becoming increasingly linked to environmental problems. With a technology relying heavily on the combustion of hydrocarbons, notably with the internal combustion engine, the impacts of transportation over environmental systems has increased. This has reached a point where transportation activities are a dominant factor behind the emission of most pollutants and thus their impacts on the environment. The most important impacts of transport on the environment relate to climate change, air quality, noise, water quality, soil quality, biodiversity and land take. In this work, the interest is focused on the impacts on climate change and air quality.

Concerning climate change, the transport industry releases several million tons of gases each year into the atmosphere. These include lead (Pb), carbon monoxide (CO), carbon dioxide (CO₂; not a pollutant), methane (CH₄), nitrogen oxides (NOₓ), chlorofluorocarbons (CFCs), perfluorocarbons (PFCs), silicon tetraflouride (SF₆), benzene and volatile components (BTX), heavy metals (zinc, chrome, copper and cadmium) and particulate matters (ash, dust). CO₂ is a byproduct of any engine that burns carbon-based fossil fuels. Air quality is affected by highway vehicles, marine engines, locomotives and aircraft. These are the sources of pollution in the form of gas and particulate matters emissions that causes damage to human health. Toxic air pollutants are associated with cancer, cardiovascular, respiratory and neurological diseases. Carbon monoxide (CO) when inhale affects bloodstream, reduces the availability of oxygen and can be extremely harmful to public health. An emission of nitrogen dioxide (NO₂) from transportation sources reduces lung function, affects the respiratory immune defense system and increases the risk of respiratory problems. The emissions of sulphur dioxide (SO₂) and nitrogen oxides (NOx) in the atmosphere form various acidic compounds that when mixed in cloud water creates acid rain.

The Mexican greenhouse gas emissions inventory for the period 1990 – 2002 report that total CO₂ emissions generated by the transport sector in 2002 were 114.3 million tons. Truck transportation accounted for 91% of the total. Truck transportation had also important contributions of NOₓ, PM10 and PM2.5. Transporte Limpio is a Mexican voluntary program developed by SEMARNAT, SCT CONUEE and representatives of the industry. It has the objectives of reducing fuel consumption, decreasing greenhouse emissions and operating cost.

Several strategies to reduce the impact of transportation on the environment are recommended by Murphy, et al. (2003) and Yano, et al. (2008). A partial list of these is given below.

- Reduce consumption and recycle materials whenever possible
- Redesign logistical system components for greater environmental efficiency
- Reject suppliers who lack environmental concerns
- Increase the education and training of company personnel
Companies such as Walmart, Apple, HP and others have delineated sustainability improvement strategies for their supply chains. These strategies include as a vital element, initiatives with the purpose of increasing sustainability in their distribution operations. Table 1 provides a brief description of these strategies. In summary, the strategies deployed consist of changing transportation modes, developing truck technology environmentally friendly and new packaging schemes that reduce transportation needs.

Table 1: Description of companies’ transport sustainability strategies

<table>
<thead>
<tr>
<th>Company</th>
<th>Brief Strategy Description</th>
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<tr>
<td>WALMART</td>
<td>- Partner with Daimler Trucks North America to build a hybrid-electric freightliner cascadia.</td>
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<tr>
<td></td>
<td>- Partner with Arvin Meritor to test a full-propulsion, dual-mode diesel-electric hybrid truck.</td>
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<td></td>
<td>- Testing trucks running on reclaimed brown waste cooking grease.</td>
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<tr>
<td></td>
<td>- Use trailer side skirts, aerodynamic tractor package and tag axles.</td>
</tr>
<tr>
<td>Hewlett Packard</td>
<td>- Reducing weight load replacing wooden pallets by plastic ones.</td>
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<tr>
<td></td>
<td>- Moving from air and truck freight to ocean and rail freight.</td>
</tr>
<tr>
<td>Apple</td>
<td>- Reducing transportation needs with new smaller and lighter packaging scheme.</td>
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3. Concepts and Methodology

In order to obtain efficient and sustainable transportation activities, it is necessary to identify waste, develop a strategy for eliminating it, and implement and control it. A scheme for achieving a greater level of transportation efficiency is described in Villarreal (2012). The author suggests the utilization of the Transportation Value Stream Map, (TVSM), to identify efficiency related waste. This tool includes the estimation of the TOVE index and the corresponding efficiency factors: administrative availability, operating availability, performance and quality. As suggested by Norton (2007) to form the sustainable value stream map (SVSM), the TVSM can be also extended to include environmental wastes to obtain the Sustainable TVSM, to be represented by STVSM. The scheme provided by Villarreal (2012) can be modified to incorporate the identification of environmental wastes and the design of strategies to eliminate them. As found by Norton (2007) certain strategies can be excellent for eliminating overall supply chain waste, but they may generate more environmental waste. Thus, it would be of interest to know if this could also happen in the transportation case. If so, it would be interesting to determine strategies in terms of both objectives: Maximize transportation efficiency and increase transportation sustainability. An initial scheme suggested is described as follows.

- Develop strategy for improving transportation efficiency as suggested by Villarreal (2012).
- Structure a strategy to increase transportation sustainability.
- Obtain a compromised strategy.
In order to extend the TVSM to consider environmental issues it is necessary to specify the set of particular wastes that will be considered. The selected efficiency wastes are all the considered to estimate the TOVE index. Preliminarily, the environmental wastes chosen are those associated to air quality, climate change and material waste that result from packaging products. Figure 2 shows an example of the structure of the proposed STVSM. An important aspect to consider would be the estimation of the values for the environmental wastes.

Even though, it is desirable to have a zero level of air quality and climate change wastes, there is also permitted levels of these concepts by Governments. In this case, one would start considering the excess over these limits as waste. The estimation can also be indirect or direct. Indirect estimates are obtained by using specialized software such as MOBILE6 Mexico, IVE and COPERT or from overall average figures at city or country level. These estimates can be used for planning and/or strategy evaluation purposes. Direct estimates for wastes are given by actually measuring them by utilizing measurement instruments and tools. Among these are passive samplers, bubbler systems, chemi-luminescence and remote sensing equipment.

4. Implementation and Results

This section is based on the work carried out by Molina et al. (2012). It is devoted to describe the application of the previous scheme in the routing operations of UPS in the metropolitan area of Monterrey, Mexico. The market area consists of about 4,000 daily clients with an average volume of 4,500 packages per day. These are delivered through 28 to 32 daily routes. Among the type of services provided are: International and National, Guarantee time and date deliveries, Fixed time pickup services, and Call in pick up services.

The operations centers in UPS Mexico are mainly concentrated in Mexico, D.F., Guadalajara and Monterrey. The performance level of these operations centers has deteriorated in 2011 and the current year. The main contributor to this situation has been the operations in Monterrey. About 74% of the National late routes are from Monterrey operations center. This situation has led to an increasing level of unsatisfied customer services, monetary penalties and an additional 23% of labor cost required to execute the services. Furthermore, an important increase of kilometers per customer stop has been experienced in 2012, impacting fuel consumption and cost significantly. UPS operations performance is measured with an index of efficiency. This is obtained by averaging the number of stops per vehicle in a route, the amount of customer stops per kilometer per vehicle and the number of customer stops per route per hour. This index has decreased 7% in the last year and upper management is very concerned about this trend.

On the other hand, UPS Mexico has expressed concern about the environmental impact that its operations have. This issue led the company to participate in the project Transporte Limpio (Clean Transportation), which is a national project undertaken by the Mexican Government to promote and support Mexican organizations on their efforts to achieve sustainable operations. Due to the previous considerations UPS Mexico decided to start a project with the purpose of defining relevant environmental indicators, the status of their current levels, and the delineation of a strategy to improve the environmental impact. The current project was required to analyze the situation and to come up with solutions to increase operations efficiency and to delineate an environmental improvement strategy.

4.1. Mapping the Transportation Process

The first step of the methodology is to map the transportation processes of interest which in this case correspond to the vehicle routing operations from Monterrey operations center. The current sustainable TVSM for the routing operation is shown in Figure 2. This includes a follow up of the trucks inside the warehouse until a new Journey is initiated.

4.2. Define efficiency improvement strategy

The average journey time for the distribution of goods from the Monterrey DC to its corresponding customers is 10.8 hrs increasing the cost associated to overtime labor very significantly. All the activities included in the process from preparing the routes, serving the stores until closing every route are executed during the journey, i.e. all are internal. Internal NIT activities take 3.2 hrs on average about 30% of journey time. The average number of customers served by a route is 61.
Figure 2: Current Sustainable Transportation Value Stream Map for UPS Routing Operations

The TOVE index is estimated at 5.8%. The factors with greatest areas for improvement are administrative availability with 45% and Performance factor with 27%. The quality factor is estimated at 58% due mainly to a 6.5% of demand not satisfied and 36% of customers served outside their time windows.

One of the main areas for improving in this case is to increase the administrative availability efficiency. The main waste that drives this factor down is the unplanned truck time of 13.2 hours. The waste that impacts the most operating availability efficiency is internal NIT activities that account for 3.2 hrs.

Figure 3: Sub-utilization of truck capacity

The best option to increase performance is the reduction of fill loss waste of 60.5%. This is illustrated in Figure 3. Fill loss waste results because the volume of packages handled by each route is lower than the truck capacity. In this case, this represents an opportunity if the number of clients served by each route is increased. However, this is not possible at the moment because the time required to serve them is greater than the normal journey time of eight hours. Also, the excess distance travelled waste of 28.4% represents an important area for improvement. This last waste is the result of several events and situations. First, the current procedure for assigning customer orders to a
route is based on postal codes. As a result, routes overlap each other as shown in Figure 4. Once assigned, customer visits are sequenced by each driver according to his experience and criterion. This scheme does not insure an optimal solution to the problem. In addition, package loading is executed with no relation to the sequence and without enough care to locate packages of the same customer together. This results in having several visits to the same customer in the same route.

Figure 4: Description of Current and Future Routes in San Nicolas Zone

Finally, the company has about 58% of preferred customers. This type of customer is supposed to handle package volume every day. Hence, they are visited by routes always without any notice or knowledge of his demand. Because the data base of this type of customers is not updated, routes are currently visiting about 25% of customers that should not be preferred any more, resulting in "null" visits. The strategy established to decrease the main wastes identified is originally aimed to improve significantly both the operating availability and performance factors. This consists of the following initiatives:

- Improving the assignment of customers to routes.
- Reducing excess distance travelled by better customer sequencing in each route.
- Updating the status of preferred customer.
- Sequence package loading according to customer sequence.
- Re-assigning NIT activities to warehousing operators.

Once these initiatives are implemented the responsible management of the company will assess the possibility of increasing administrative availability by scheduling at least two journeys per truck.

4.3. Define environmental improvement strategy

As pointed out earlier, UPS Mexico has expressed concern about the environmental impact that its operations have. This issue led the company to participate in the project Transporte Limpio (Clean Transportation). This is a national project undertaken by the Mexican Government to promote and support Mexican organizations on their efforts to achieve sustainable operations. Due to the previous considerations UPS México decided to start a project with the purpose of defining relevant environmental indicators, the status of their current levels, and the delineation of a strategy to improve the environmental impact.
As part of the initial stage, the environmental wastes selected by the company are those related with air quality, greenhouse gasses, packaging and PET materials. The main greenhouse element is CO₂. Air quality components chosen are NOx, CO, HC, PM10 and PM2.5 and SO₂. In addition, packaging and PET materials are also considered. Current values for the previous environmental wastes were obtained by using available gas emission factors for the Monterrey metropolitan area given by Aguilar-Gomez et al., (2009). The levels of packaging and PET materials generated by the routing operations are estimated for the last month. These estimates are provided in Figure 2. At this stage, the previous values are established as reference and upper limit. Improvement objectives will be set based on these references. In the future, a reference model similar to the one for the air quality index given by the US Environmental Protection Agency (EPA) will be used to calculate an index to measure the environmental impact of transport operations.

The preliminary strategy for improving sustainability of the routing operations was defined based on a comparative study done for similar operations. The environmental programs delineated by DHL, Fedex and UPS in their North American operations were analyzed and used as the basis. In summary, their strategies are based on the development of more efficient routing schemes, the use of hybrid vehicles, alternative fuels and the development of new technologies. Therefore, the company decided to structure a short and a long term strategy. The initial stage of the strategy is based on increasing routing efficiency during the following three years. The long term aspect will be to consider the elements of their North American operations. In particular those where important investments are required.

4.4. Strategy implementation and projected results

The implementation of the previously described strategies is under way. The initial stage consisted in the development of a pilot project carried out in the San Nicolas zone routes. Since the firm did not have a computational tool such as UPS Roadnet, it was decided to develop a scheme to increase route efficiency. The results obtained from this pilot test are used to obtain the future STVSM illustrated in Figure 5.

The management started the implementation with the reassignment of NIT activities to new warehousing personnel. This action insured that the driver and his assistant would practically dedicate their journey to serve customers. The cost for extra labor time is eliminated.

The vehicle routing problem was attacked in an aggregated manner. Initially, the preferred customer and customer time windows database was updated. This action eliminated 25% of current fixed visits to customers that did not have a steady demand. Then, customers were assigned to their location zones called “colonias”. Afterwards, routes were designed for these zones using the software My Route Online. This scheme provided the sequence in which the “colonias” had to be visited. Even though this scheme does not insure optimal solutions it generates feasible and much better routes than the current ones. It is also a scheme that is not very costly.

The resulting routes became more “clustered”, including customers located much closer to each other as shown in Figure 4. Performance efficiency increased from 26.6 to 35.2%. Excess travelled distance was reduced to 12.2% and time taken between customers decreased 15%. The number of customers visited per route increased 5%. This impacts favorably fill loss in 3.4%. Package loading is now done according to customer service sequence eliminating the need for customer re-visits.

The operating availability efficiency increased from 84 to 95% due mainly to the elimination of the number of preferred customers with fixed visit that were not satisfying the condition of continuous demand. The quality efficiency index was improved from 58% to 71% by increasing the % of demand satisfied. Journey time was reduced to the required normal eight hours. Hence, the time not programmed for trucks increased to 13.7 hours per day.

Increasing routing efficiency had a positive impact on the level of sustainability as shown in Table 2. The amount of CO₂ generated per route per day is originally 51.94 kgs. It is estimated that this can be diminish by 11.6% with the increase in efficiency. The same behavior is shown by the rest of the elements.
The previously described results are considered promising. The management of the company has decided to proceed with the implementation of the project in all the seven zones included in the Monterrey metropolitan area during the rest of this year. It is also planning to implement the project in the rest of the Mexican operations next year. Included in this implementation stage are the following suggestions illustrated in Table 3. The use of smaller vehicles must improve both: the level of route efficiency by reducing the fill loss waste and the sustainability by decreasing fuel consumption. Implementing night routes will facilitate driving conditions because traffic congestion is practically eliminated. Additionally, night routes provides the opportunity for increasing vehicle utilization. This is possible since vehicles have almost 14 hours of idle time per day. Night routes reduce the time taken to reach customers and fuel consumption. Driver training with the objective of changing driving habits has the purpose of reducing fuel consumption similar to the EcoDrive project of FedEx. Finally, the purchase of UPS Roadnet will enable UPS Mexico to design dynamic routes for all the Mexican operations at the customer level. This will further improve performance efficiency by decreasing excess traveling distance.

Table 3: Future suggestions to include in strategy

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<thead>
<tr>
<th>Suggestion</th>
<th>Efficiency</th>
<th>Sustainability</th>
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<tbody>
<tr>
<td>Night routes</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Use smaller vehicle</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Driver training for sustainability</td>
<td>X</td>
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</tr>
<tr>
<td>Purchase of UPS Roadnet</td>
<td>X</td>
<td>X</td>
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</table>
5. Conclusions

This paper deals with an application of an improvement methodology to the field of routing operations. This is used to identify and eliminate specific waste associated with the transportation of goods to improve its efficiency and/or sustainability. This is applied to the distribution of packages of a Mexican firm leader in this sector.

The application is one of the first efforts to treat the definition of a strategy for increasing efficiency and sustainability simultaneously. The most significant efficiency improvement areas obtained are related to the performance efficiency factor. The particular wastes to be reduced are: excess route distance, truck fill loss capacity and the reassignment of NIT activities from internal to external status. In this case, the short term strategy defined by the company consisted of initiatives to increase efficient routes and that would improve sustainability. The application of this improvement scheme proved to be helpful to provide a guide to support management on investment decision making. The strategy for reducing waste is in process of being implemented. The results obtained from the analysis and preliminary pilot implementation actions give the responsible management high hopes and confidence that the overall initiative will be very successful.

References


