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Improving Agility in Distribution Operations

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Abstract

Distribution agility is a key aspect that a refrigerated food processing company must have to satisfy customers and keep its competitive level. This work describes the strategy of Tyson, a leading Mexican food processor, to decrease order lead time and increase "food freshness time". This is based on the application of lean initiatives on the distribution network located on northeastern Mexico. Lean projects are defined based on the identification of efficiency wastes in the transportation legs of the network as well as in the warehousing facilities. The implementation of the improvement initiatives is still in progress but projected and available results are provided.

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

1. Introduction
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 agile supply chain is suitable for selling innovative or perishable products. In addition, the market has become more volatile and dynamic, and requires higher levels of competitive factors. Firms have to be more agile to compete successfully under these conditions. This paper describes the efforts of a Mexican company that faces competitive pressures similar to the ones just described, and in particular, with the need to decrease order lead time significantly to maintain its position as a supplier

This report is assembled into five sections. The following section provides a review of relevant literature related to the problem of concern. The second section describes briefly the process considered for the solution. Then, the application of this process is described, and finally, the last sections provide results and conclusions.

2. Previous Research
As suggested by Tersine and Hummingbird (1995), the management of order lead time can be a competitive advantage. Time based competition refers to the ability to deliver products or services faster than the competitors. Order 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. Traditionally, product flows are managed by different organizational units that work independently and are poorly coordinated. Information about timing and quantity of product flows is managed by transactional systems that are not integrated, originating reactive behaviour and a lack of consolidation opportunities.

The 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 has been around for some time. What is now clear is that time compression is a performance driver which initially enhances the competitiveness of individual work processes and then of complete industrial businesses. When coupled with open information flow, time compression can multiply to have an even greater effect on supply chain competitiveness. Today, it is no longer sufficient to be a competent business in isolation: it is also necessary to be associated with world-class supply chains if we are to survive. Thus, we can conclude that the supply chain process is greatly improved by concentrating on the streamlining of material, information and cash flow, simplifying decision-making procedures and eliminating as many non - value added operations/delays as possible.

Towill and Christopher (2002) suggest that key drivers resulting from time compression include:

• Improved demand forecasting;
• Quicker defect detection;
• Quicker to market; and
• Shifting decoupling point towards the customer.

At the tactical level, time compression can be achieved via industrial engineering, production engineering, information technology and operation engineering routes, as shown in Table No. 1 (Towill and Christopher 2002).This is a sample of tools which many companies are currently employing as part of their business process improvement programmes.

Table No. 1. Practical ways to achieve time compression

Strategy	Technique
Industrial Engineering	- Set-up time reduction - Handling methods. - Product design.
Production engineering	- Process integration. - Sequencing.
Information Technology	- EDI. - Quicker and more accurate data capture.
Operations engineering	- Kanban. - JIT Supplies.

The design of a supply chain strategy requires the knowledge of the company´s competitive factors. The concepts of market qualifiers and order winners developed by Hill (1993) are used to facilitate manufacturing strategy making. This is extended by Mason, et al. (2000) for the determination of supply chain strategy. They suggested the utilization of a lean strategy as the best option when cost is the competitive factor, and an agile strategy when the competitive factor is customer service. 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 and Romme (1992) is relevant for the previous strategy making process. It is defined as the farthest upstream position in the supply chain where the customer order is satisfied. As suggested by Christopher and Towill (2001), Mason et al. (2000) and Olagher (2003), 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, the idea that lean methodologies are important contributors to the creation of agile systems is given by Christopher and Towill (2001).

The origin of waste elimination is associated with the concept of lean manufacturing. This can be traced back to the 1930´s when Henry Ford revolutionised car manufacturing with the introduction of mass production. The most important contribution to the development of lean manufacturing techniques since then came from the Japanese automotive firm Toyota. Its success is based on its renowned Toyota Production System. This system is based on a philosophy of continuous improvement where the elimination of waste is fundamental. The process of elimination is facilitated by the definition of seven forms of waste, activities that add cost but no value: production of goods not yet ordered; waiting; rectification of mistakes; excess processing; excess movement; excess transport; and excess stock.

It has been shown by Jones et al. (1997) that these seven types of waste need to be adapted for the supply chain environment. A methodology for extending the lean approach to enable waste elimination throughout the supply chain is developed by Hines and Taylor (2000) and Rother and Shook (199) recommend the use of the value stream map (VSM) and the supply chain mapping toolkit described by Hines and Taylor (2000) as fundamental aids for identifying waste.

The lean movement can be further expanded specific areas of supply chain management. Transportation and warehousing represent good opportunities for the application and could give important benefits if applied properly. It is well known that both activities are classified as waste. However, when markets are distant, these are certainly necessary activities to attain competitive customer service levels. Most distribution networks have significant waste and unnecessary costs (Ackerman 2007 and McKinnon et al. 2003). For the identification of waste between facilities and installations in a supply chain, Value Stream Mapping for the extended enterprise is recommended by Jones and Womack (2003). When mapping at the supply chain level, unnecessary inventories and transportation become important wastes. Unnecessary transportation waste is related to location decisions for the improvement of performance at given points of the supply chain. Therefore, the solutions suggested for its elimination are concerned with the relocation and consolidation of facilities, a change of transportation mode or the implementation of milk runs. In addition to transportation, warehousing is another important part of a distribution network. Value stream mapping at the supply chain level emphasizes on the identification of inventory waste. As shown by Villarreal, et al. (2012b), this approach does not consider the elimination of waste in both; transport and warehousing operations. They further suggest an approach for the reduction of waste based on the improvement of distribution operations efficiency. This approach 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 and suggested by Nakajima (1988).

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 previous measure has also been modified by Villarreal (2012a). In this case, the OVE measure is adapted to consider total calendar time as suggested by Jeong, et al. (2003). The proposed measure is called Total Operational Vehicle Effectiveness and it is 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.

The OEE measure is also adapted to analyze warehousing operations by Garza et al. (2010). 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. 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. The extended VSM to include the supply chain as a system is suggested by Jones and Womack (2003). Such VSM is considered with the addition of information on the efficiency measures for the facilities or installations that form the chain. As is shown in Figure 1, 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. Thus, is suggested the application of Value Stream Mapping for the operations of each installation or transport route. The VSM suggested for transportation is based upon the work of Villarreal (2012a). The VSM considered for warehousing is suggested by Garza et al. (2010).

3. Description of Overall Waste Reduction Scheme

This work suggests a two-stage, top-down scheme to guide waste elimination projects for improving distribution efficiency. 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. Next, the waste identification phase is enriched with the use of value stream mapping. There is 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. The final phase consists of the implementation of the strategies and control of results.

The application of the previous methodology is illustrated in the following section. This is done with information gathered from the efforts undertaken by a Mexican producer of frozen and refrigerated foods. The goal of the projects was to identify and implement projects for reducing order cycle time without increases of distribution costs.

4. Implementation and Results

This section is devoted to describe the application of the previous scheme in the distributing operations of Tyson in the northeastern of Mexico. The market area consists of about 99 regional clients with an average volume of 167 tons per week. Routes are divided into local (inside suburban Monterrey area) routes and regional routes serving neighboring cities. The work described is centered on the regional routes.

4.1. Mapping the Northeastern Supply Chain.

Tyson is a company that processes food on the basis of customer orders. Its decoupling point is located at the raw material warehouse. Customer orders received every day are programmed for processing at the plant located in Gomez Palacio, Durango. These are sent to the northeastern distribution center located in Apodaca. These orders are sent to the customers next day through several milk routes. Currently, each customer is served three times per week.

Total order cycle time is about 60.8 hrs as shown in Figure 1. 20% of this time is due to processing. Transporting takes 36% and warehousing the rest. The product stays in the warehouse 24 hrs on average, about 39% of total cycle time. Tyson is concerned about food “freshness” or perishability. This is the time during which food stays in good condition before becoming rotten. Total estimated freshness time (FT) is seven days. This starts once product leaves the plant to the distribution center. FT is reduced by two days due to the time taken to go through the distribution network, leaving only five days of food life to retailers and end customers. The main concern for Tyson is to become more agile by reducing order cycle time. This will enable Tyson to design more efficient delivery strategies and/or increase FT at retailers and the end customers.

The main areas of opportunity to decrease cycle time are in the warehousing and milk routing operations. Baker 2006 recommends the implementation of cross-docking and in-transit merging facilities as a key part of agile supply chains. In our case, there is the possibility of modifying the role of the Apodaca facility from that of keeping inventory to a cross-docking facility. As for the routing operation, the objective is to improve its efficiency. Detailed VSM diagrams are elaborated to identify transportation efficiency wastes and the feasibility of transforming the warehousing facility to a cross-docking installation. These are shown in Figure 1. First, the product lead time at the warehouse totals 28.12 hrs. The handling activities require 4.12 hrs and the rest of the time, the product stays as inventory. After carrying out a methods and time measurement study, and a layout analysis, the feasibility of cross-docking the product instead of keeping it as inventory is validated. This modification would provide one more day of FT to retailers and end customers. With respect to the routing operation, the TOVE Index is estimated at 24% with the availability efficiency factors, with 60% both, having important areas for improvement. On average, refrigerated trucks are not scheduled for distribution 8.5 hrs per day. The most important waste considered in the operating availability efficiency is the excess customer service time of 50%. The performance efficiency factor is estimated in 70% with fill loss waste being the only area for further improvement.

4.2 Designing an improvement strategy

As shown in Table 1, the improvement strategy consists of two main initiatives: The modification of the role of the warehouse facility, and the reduction of reduction of excess customer serving time.

Table 1 Description of improvement strategy

Initiative	Impact
Modify role to cross-dock	- Increase FT by 24 hrs - Reduce customer routing frequency - Reduce fill loss - Decrease food scrap
Reduce excess customer service time	- Increase FT - Reduce journey time and labor cost

The change of role of the current warehouse is the main improvement initiative. The feasibility of becoming a cross-dock facility depends on the level of coordination and synchronization between the activities of food unloading, classifying and loading. All these activities must be executed within the time frame assigned for it in the overall daily activity program of the facility. The first step in the implementation consisted on re-designing the facility layout. Product is now located according to the requirements of each route to facilitate and speed up product loading.

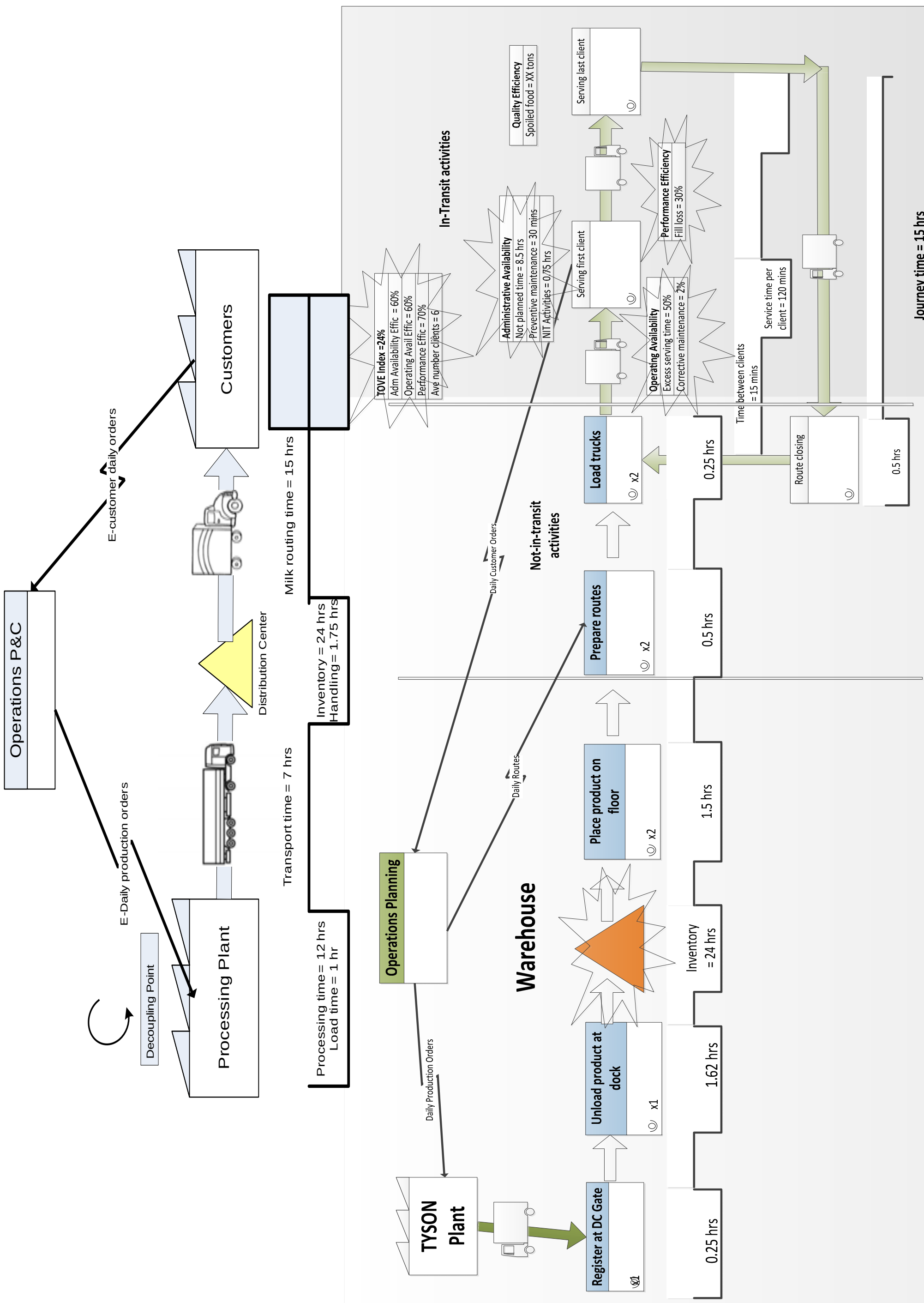

Figure 1 Current detailed VSM for warehousing and routing operations

Food unloading at the cross-dock is also improved because it was already loaded at the plant according to the previously defined routes. This implies a full route visibility throughout the distribution network which enables also the required coordination of truck arrivals and departures.

Current distribution scheme is such that each retailer is supplied three times per week. This could be either Mo-Wed-Fri or Tue-Thu-Sat. Every shipment is equivalent to a two-day demand. This supply schedule leaves about three days of FT to end customers as shown in Figure 2. The impact of reducing FT one day in transit would either be used to enhance customer service or make routing operations more efficient. Leaving the current supply schedule unchanged increases FT time to end customers. If the supply schedule is modified from three times to two times per week, it will reduce fill loss and the number of routes per week required to serve the same demand. This option makes current routing operations more efficient.

Figure 2 Description of FT for current and proposed supply schedule

Most of the excess serving time is a result of the lack of comunication between Tyson and its customers. They do not have any idea when the truck will arrive. Tyson decided to inform each customer of the daily routing schedule. In addition, each driver had to update the arriving time during the journey. This way, the customer would be prepared to receive the load and help to speed up the unloading activity.

4.3 Strategy implementation and projected results.

The implementation of the previously described strategy is under way. The initial stage consists of carrying out a pilot test with three routes during one month. This project serves to identify pitfalls, misunderstandings and to validate expected results. The second front consists on decreasing excess customer serving time. This includes the implementation of a project that considers the application of technology to communicate with customers. Serving time was reduced 50% during the pilot trials. The previous result impacted positively the total journey time passing from an average of 15 hours to about 10 hours during the pilot project.

Figure 3 illustrates the future projected value stream map for Tyson regional routes. First, total cycle time decreases 46% as a result of the redefinition of the warehouse facility to a cross-docking facility. From the transportation point of view, there is a projection of the efficiencies and flow times based on the results from the pilot program considering all the regional routes. It is expected that the average journey time is reduced 50% due to a reduction of 50% in excess customer serving time.This impacts favorably decreasing the cost of labor and increasing truck availability for potential additional daily routing. The performance efficiency improves from 70 to 92%. This is due to an important reduction of the fill loss waste. Management will also consider the utilization of trucks for two routes daily impacting favorably on the administrative availability efficiency. Finally, there will be a periodic updating of routes to consider new store introduction.

5. Conclusions

This paper deals with an application of lean methodology to the field of supply chain management, and in particular, to routing operations. It contributes with a two-level approach to identify and eliminate specific waste associated with the chain and the transportation of goods to improve its efficiency. This is applied to the distribution network of Tyson, a Mexican company leader in the production and distribution of frozen and refrigerated food. The network of concern is located at the Northeast of Mexico.

The objective of the study is to improve the level of agility of the chain. This increases the degree of food freshness, an important factor that can be used to improve customer service and supply chain efficiency. The increase of agility is achieved by applying a lean strategy. At the chain level, the most important waste identified is the time spent by food as inventory during one day. This is eliminated by modifying the function of the facility from a warehousing role to become a cross-dock facility. The elimination of waste is continued at the operational level of the routing operations. The goal here is to identify efficiency wastes. The development of a TVSM of the northeastern regional routes resulted in the identification of important excess customer serving time and fill loss.

The level of agility for the distribution network is assessed by the implementation of a pilot project. The results include an important reduction of total cycle time of 46%. This enabled Tyson to modify its distribution strategy to obtain efficiency benefits. A reduction of 35% in the number of routes is achieved. Fill loss is decreased 60% and routing cost is also reduced by 31%. These results have been considered as very promising by the management of the company. It gives them high hopes and confidence that the overall initiative will be very successful.

References

Ackerman, K., *Lean Warehousing*, Ackerman Publications, 2007.

Christopher, M. and Towill, D., An integrated model for the design of agile supply chains, *International Journal of Physical Distribution Logistics* Management, Vol. **31**, pp. 235–246, 2001.

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

Garza, F.B., López, N. & Guerra C., *Incremento de la Productividad del Centro de Almacenamiento y Distribución de la Región Noreste en una Empresa Alimenticia,* B.S. Thesis, Departamento de Ingeniería, Universidad de Monterrey, 2010.

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

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

Hoekstra, S. And Romme, J., *Integrated Logistics Structures: Developing Customer Oriented Goods Flow*, McGraw Hill, London, U.K., 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, 2003.

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

Jones, D.T., Hines, P. & Rich, N., Lean Logistics, *International Journal of Physical Distribution and Logistics Management*, Vol. 27, No. 3, pp. 153-73, 1997.

Mason-Jones, R., Naylor, B. and Towill, D.R., Engineering the Leagile Supply Chain, *International Journal of Agile Management Systems*, Vol. 2, No. 1, pp. 54-61, 2000.

McKinnon, A.C., Ge, Y. & Leuchars, D., *Key Performance Indicators for the Food Supply Chain*, Transport Energy Benchmarking Guide 78, London, Department for Transport, 2003.

Nakajima, S., *Introduction to TPM*, Productivity Press, Cambridge, MA., 1988.

Olagher, J., Strategic Positioning of the Order Penetration Point, *International Journal of Production Economics*, Vol. 85, 2003.

Rother, M. & Shook, J., *Learning to See*, Lean Enterprise Institute, 1999.

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.

Tersine, R.J. and Hummingbird, E.A., Lead Time Reduction: The Search for Competitive Advantage, *International Journal of Operations and Production Management*, Vol. 15, No. 2, 1995.

Towill, D. and Christopher, M., The Supply Chain Strategy Conundrum: To be Lean *Or* Agile or To be Lean and Agile?, *International Journal of Logistics: Research and Applications*, Vol. 5, No. 3, 2002.

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

Villarreal, 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 (b).

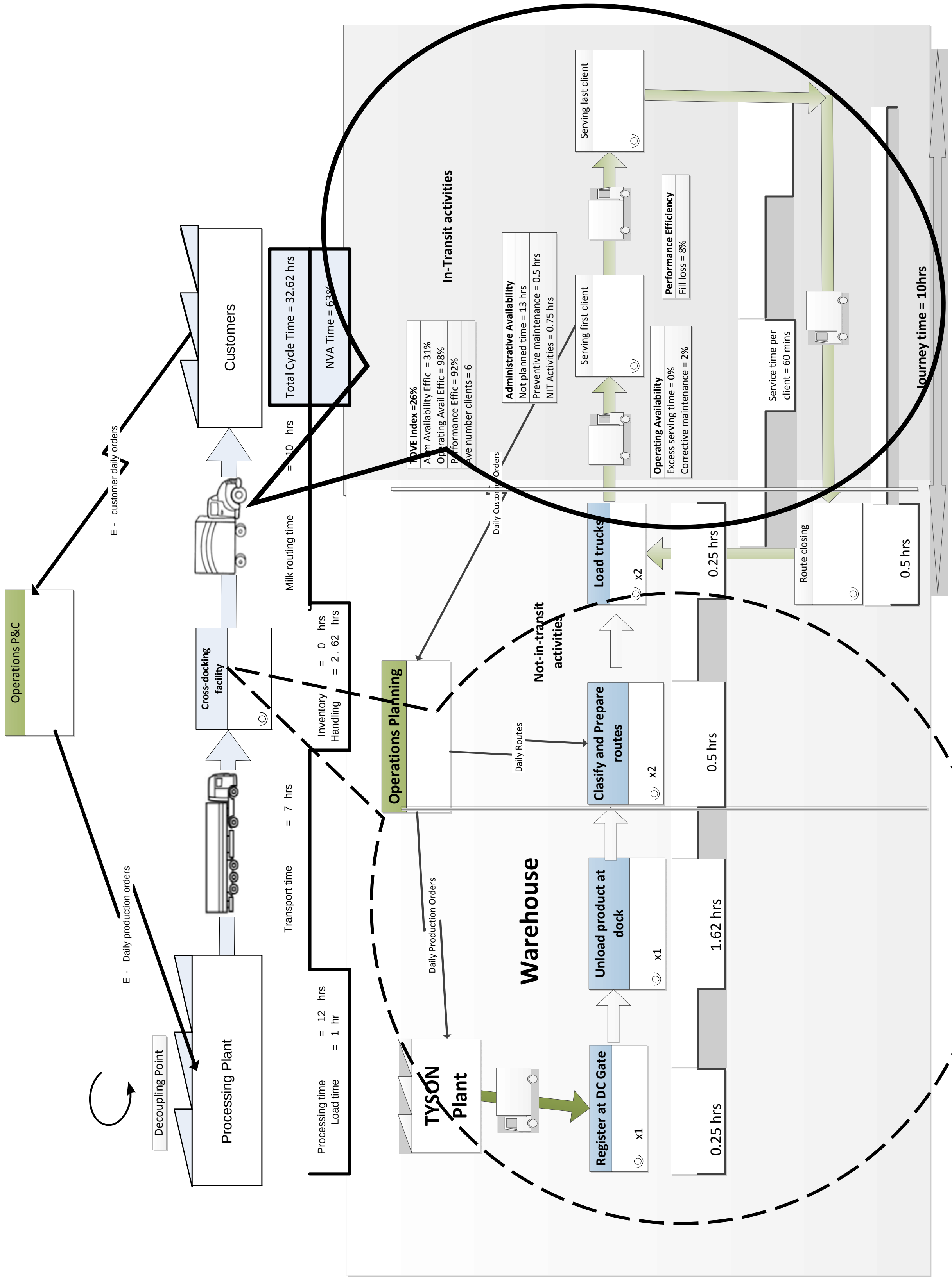

Figure 3 Future Projected Value Stream Map