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Assessment of VSM Scenarios by Simulation of Logistics Systems in Petrochemical Company

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Abstract. Believe that VSM involves the concurrent improve of processes, organizations, and their supporting information systems to achieve radical improvement in time, cost, quality, and customer's regard for the company's products and services. Nowadays, simulation is the most important way to do VSM and improving logistics processes. A time study was performed by measuring the time duration per process and identifying different time drivers from direct observation, interviews and time templates. These results were then consolidated in to a generalized framework (simulated process) that was used to optimize material handling time and cost in logistics processes. In this paper, the process of loading, unloading and movement of the containers, in the firm has been studied. The aim of this study is to determine the maximum efficiency of process and movement equipment's and also to minimized the cost and time for this purpose. Simulation and VSM processes have been used to study this system regarding the complexities of the logistics processes. At the end by designing and implementing of model in ARENA software, the results of implemented simulation, by study of alternatives have been analyzed. Finally, current optimization leads to increase efficiency in the firm's logistics and reduction of approximately 12% of the logistics costs and 35% of process cycle time.

Keywords: Value Stream Mapping, Simulation, Logistics Equipment, Optimization, Material Handling Cost.

1. Introduction

Value Stream Mapping (VSM) is used to draw current state mapping and future state mapping with material, information, and time flows (Chen, 2013). Value stream mapping (VSM) is an important technique used in lean manufacturing to identify and visualize waste (Brown, *et al.*, 2014). Besides shortening of lead time, cost reduction is also imperative for every company, so monitoring and control of manufacturing cost over the time can be driving force for improvement (Gracanin, *et al.*, 2014).

Over the last decades, there has been a significant growth of global freight transport due to the enormous commercial trade. Over 60% of worldwide deep-sea cargo is transported by containers. The management of freight transport needs to accommodate this increasing supply of containers (Xin, *et al.*, 2014). Jianbin Xin (2014), the performance of container terminals needs to be improved to handle the growth of transported containers and maintain port sustainability. This paper provides a methodology for improving the handling capacity of an automated container terminal in an energy-efficient way.

The behavior of a container terminal is considered as consisting of a higher level and a lower level represented by discrete-event dynamics and continuous-time dynamics, respectively. These dynamics represent the behavior of a large number of terminal equipment. The dynamics need to be controlled. For controlling the higher level dynamics, a minimal make span problem is solved. For this, the minimal time required by equipment for performing an operation at the lower level is needed. The minimal time for performing an operation at the lower level is obtained using Pontryagin's Minimum Principle. The actual operation time allowed by the higher level for processing an operation at the lower level is subsequently determined by a scheduling algorithm at the higher level. Given an actual operation time, the lower level dynamics are controlled using optimal control to achieve minimal energy consumption while respecting the time constraint. Simulation studies illustrate how energy-efficient management of equipment for the minimal make span could be obtained using the proposed methodology (Xin, *et al.*, 2014). One advantage of existing petrochemical plants in South Pars Special Economic Energy Zone, near the sea and export terminals, which are one of the exports of container terminals by terminal equipment, can be done. Export logistics process in the firm in 2006 by a group of Iranian engineers designed. However, after several years of operation of the logistics process, VSM can be useful tool for improvement. Simulation and VSM in this paper are tools for improving efficiency of logistics process from the manufacturing plant to the export terminal. Although this complex logistics costs are low compared to other manufacturing companies inside Iran, but we can use the VSM and simulation to reduce cost and time. Fritzson David (2012), the main purpose of the thesis is to analyze what drives time in the Control Towers and how much. In order to fulfill this, two main sources of data were needed. Firstly, in order to increase the knowledge on what activities are performed in the CT, all processes for the customers covered in thesis were mapped and described in detail. This was made possible by observing the processes and interviewing the staff responsible for each customer, identifying which processes were executed and from there going through each step of the process in detail. Secondly, a time study was performed by measuring the time duration per process and identifying different time drivers from direct observation, interviews and time templates. These results were then consolidated in to a generalized framework that was used to create an algorithm that is supposed to calculate the basic CT manning need for a future client. This then leads to the discussion part of the thesis where improvement recommendations were suggested both in relation to pricing the CT function in a more precise and accurate way as well as general improvements identified by the CT staff and authors (Fritzson, *et al.*, 2012). Heydari Jafar (2014), Variability in lead time between successive stages which often has a great effect on Supply Chain performance occurs when production process, information systems or shipping equipment could not provide a reasonable level of consistency. Low reliability of shipping facilities or using slow and unreliable transportation modes is a major reason for lead time variability. By spending more, the supplier reduces LT variability and instead benefits from the globally optimum service level. The main contribution of this paper is about using lever of LT variability control for coordinating SC. To the best knowledge of the present authors, controlling lead time has not been applied as an incentive for coordinating SC. In addition, among the extensive literature on order quantity coordination, this paper attempts to consider service level coordination (Heydari, 2014).

2. Literature Review

It is interesting to detect the different biases-military, economic, academic, etc. An appropriate modern definition that applies to most industry might be that logistics concerns the efficient transfer of goods from the source of supply through the place of to the point of consumption in a cost-effective way whilst providing an acceptable service to the customer. It is useful, at this point, to consider logistics in the context of business and the economy as a whole. Logistics is an important activity making extensive use of the human and equipment that affect a company economy. There are a number of ways that this might happen, including reductions in transport, storage and inventory holding costs, as well as maximizing labor efficiency. This will provide cost savings through reduced overheads, better utilization of equipment and labor (Rathmell and Sturrock, 2002).

According to Fuller (2006), in the ocean containerized transportation industry, 60% of containers that crossed from Asia to North America, and 41% of those from Asia to Europe, came back empty in 2005. Movement and storage of empty equipment cost billions of dollars each year. In 2003, empty container movements accounted for 20% of the total ocean container movements at a cost more than $11 billion. The empty equipment repositioning problem also exists widely in other freight transportation industries, such as truck and rail transportation. People have proposed and tried various ways, such as information sharing, equipment pooling and equipment transportation optimization, to reduce the cost of empty equipment movements. However, since trade imbalance is the most fundamental cause of empty equipment repositioning problem and very hard to be eliminated, the problem has remained and has been seen as a curse of the transportation industry (Zhoua and Lee, 2009). In commercial supply chains, this approach forms the basis of a business model that encourages different actors to deliver a product or a service at a certain cost, quality, and time, to make a profit (Tomasini and Wassenhove, 2009). In retail stores, handling of products typically forms the largest share of the operational costs. In this article, the potential to improve store-handling efficiency is discussed by identifying the drivers for shelf stacking (i.e. given the packages and the inventory replenishment rules). Handling costs in the stores in the two retail chains investigated in this paper are equal to around 50 million euro (or 60 million dollar) per year, indicating that efficiency gains can lead to substantial cost savings as well (Donselaar, *et al.*, 2006). Value stream mapping is a method of lean manufacturing which uses symbols, metrics and arrows to show and improve the flow of inventory and information required to produce a product or service which is delivered to a consumer. A value stream map is a visual representation which enables one to determine where the waste occurs. Value stream maps are utilized to assess current manufacturing processes and create ideal and future state processes. Value stream mapping is a tool which enables a company to map the process flow that helps in identifying various factors like (Venkataraman, *et al.*, 2014); Value added time (time taken for producing the end product), Non Value added time (time taken which do not contribute to the production of end product), Cycle time (time required to perform a process) and Changeover time (time required to change tool and programming etc.).This helps in identifying and eliminating muda (waste), thereby implementing lean principles. After identifying the non-value added steps in the current state, a future state value stream map is developed which acts as blueprint for lean activities. The future state value stream map often represents a significant change compared to the way the company currently operates. The value stream map team thus develops a step by step implementation strategy to make the future state a reality. The key elements of the value stream map are shown (Venkataraman, *et al.*, 2014); The Customer and his requirements.

- Process steps.
- Process Metrics.
- Inventory.
- Supplier with material flows.
- Information and Physical flows.
- Total lead time and tact time

Gracanin (2014), emphasize importance of relationship between money and time and provide framework for value stream optimization. Brown (2014), in the paper presented the application of the Sus-VSM methodology developed by Faulkner and Badurdeen (2014) to scenarios with different manufacturing system configurations to assess its generalizability and elucidate its use in challenging conditions. The simulation process is applied to the modeling of a process, a phenomenon, or the actual system (Kelton, *et al.*, 2011). Today, for modeling the production systems, a set of methods have been developed one of which is simulation. The simulation is a method that defines, a case which has the probable condition and loss of confidence in variables and parameters, and then gives a model to determine the characters of the time variable (Banks, 1999).

The simulation discuss about the models of the complicated systems which produce acceptable output and can lead to acceptable solutions (Shokouhyar, 2005). This literature review focuses on simulation-based approaches, a special case of quantitative assessment. A variety of approaches have been constructed to simulate the effects of applying methods in manufacturing, i.e., illustrating differences between a real and ideal state, examining their impact on performance indicators (Diaz-Elsayed, *et al.*, 2013). The following variables can be examined, for the measurement and analysis of the model data (Ahmadi, 2007): Variability in lead time between successive stages which often has a great effect on supply chain performance occurs when production process, information systems or shipping equipment could not provide a reasonable level of consistency. Just in time (JIT) systems are leading systems concerning waste reduction. Delay in production process is one result of LT variability which must be eliminated according to JIT philosophy. Consider a production line which assembles several parts. In this case, the distributor can use smaller trucks to reduce variability in loading, dispatching and unloading them (Heydari, 2014). A survey of US logistics costs undertaken by Herbert W Davis & Company (2005) indicated that transport was the most important element at 45%, followed by inventory carrying cost (23%), storage/warehousing (22%) and administration (10%). These broad figures are supported by a European logistics productivity survey, produced by A T Kearney. These results, covering the major EU economies, placed transport at 41%, inventory carrying cost at 23%, warehousing at 21% and administration at 15% of overall costs. In both studies, therefore, the transport cost element of distribution was the major constituent part (Rathmell, 2002). For many companies, a key measure of success is the return on investment (ROI): the ratio between the net profit and the capital employed in the business. For improved business performance, this ratio needs to be shifted to increase profits and reduce capital employed (Rushton, 2006).

Low reliability of shipping facilities or using slow and unreliable transportation modes is a major reason for lead time variability. Although expedited shipment is more costly than regular services, it can improve quality of supply chain services (Heydari, 2014). The organizations must improve the effectiveness of its quality management system continuously, through the use of quality Policy, quality objectives, audit results, data analysis and corrective and preventive actions and also management review (Jalali, 2007). Mainly, the firm's logistics process divided to three area, final product warehouse, container yard inside firm and port container yard. This firm's product warehouse is one of the well-equipped existing warehouses in Pars Special Economic Energy Zone (PSEEZ) which has been constructed in an area of 40,770m^2 with dimension of 151x270 meters. firm's products includes various types of LDPE & HDPE grades that after packaging are stored in this warehouse which is divided into two major parts of block stock and rack stock. In block stock, pallets are kept on the ground and maximum in two vertical rows but in rack stock the pallets are kept on the multi store racks (6 vertical rows) which makes this warehouse very unique in its kind.

World's latest sophisticated machinery have been utilized for loading, unloading and transferring products into the warehouse and the export containers enabling the warehouse logistics team in adequate storing and keeping of products. For transferring products in block stock modern forklifts are used, and in the rack stock a special machine is used called VNA Turret. Total capacity of the product warehouse is 61,843 tons which 48,125 tons allocated capacity of rack stock & 13,718 ton is the capacity for block stock. In other words 44,997 pieces of pallets can be stored in this warehouse totally which 35,000 on the racks and the rest in the block area. Total capacity in firm container yard is 1200 TEU for Empty and 1200 TEU for full containers which means that firm can stock around 12000 tons product in its full container yard. In the container yard 2 special machine are used called handler and reach stacker. Single automatic trailer has been used to move container from area to other area. The firm using ERP system in all of its warehouse operations by means of registering products receipt, storage, and loading activities with scanners designed for the purpose automatically. Due to the increasing growth in containerized imports and exports, in the west of Asia and Iran, this type of transport is very important after extensive study (Parhizgar, *et al.*, 2013), a conceptual model of the terminals and warehouse was built, to make clear the aim and limit of the subject. This model is visible in Figure 1.

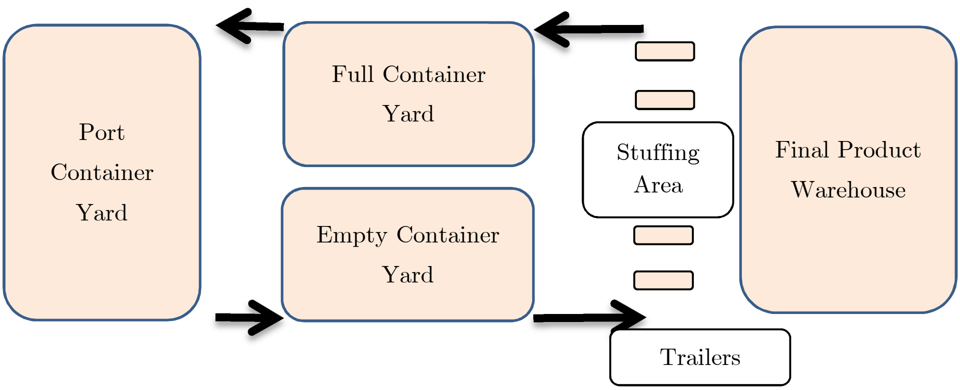

Figure 1. Conceptual Model of the Case

According to Figure 1, Empty container receive from port by trailer and upload into empty container yard, then it transfer to weighbridge and then to stuffing area to stuff palletized products with single forklift. In this location, container will be on trailer till end of stuffing time, that is very time consumption and trailers stop in that location without any adding value. To decrease time for stopping in stuffing area and move container between port and firm, installing new crane for loading/unloading of container for trailers is necessary. Then it move to weighbridge again and upload in full container yard, after stacking of container and its customs clearance, it move to port based on planning instruction and port window time. This process is shown in Basic Scenario figure with more details.

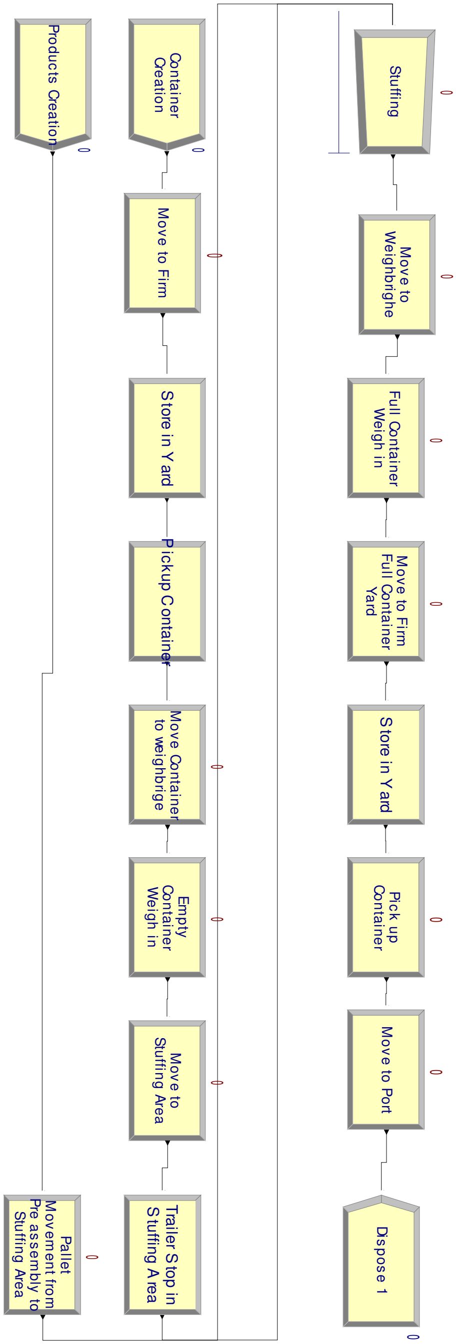

Figure 2. Basic Scenario

3. Method

In this paper, the process of loading, unloading and movement of the containers, in the firm has been studied. The aim of this study is to determine the maximum efficiency of loading, unloading and movement equipment's and also to minimized the cost for this purpose. Simulation and VSM process has been used to study this system regarding the complexities of the loading processes. Work engineering & time study is a term timing techniques and methods that provide for maximum use of manpower, equipment and material requirements for a specific job boards are used, it takes (Ahmadi, 2007). Comparison of different scenario of operation in order to determine the optimal method of operations is carried out by taking into account several criteria. One of these measures is the time to do it. The method is less time consuming than other methods is preferred (Ahmadi, 2007). Timing with stopwatch: measuring time required to perform specific activities using the stopwatch function is defined and limited direct observation over several cycles (Ahmadi, 2007). Standard Time is the time required for operations in conjunction with counting times, so additions are allowed. $\text{Standard Time} = \text{Norman Time} + \text{Permissible Surplus}$. After the start of production and related activities, data gathering can be started according to the data about the timing of these activities for estimates of the time. For this purpose, the working activities (the usefulness or not identified at the time of the production) of each was measured with the stopwatch. Time recorded in real time by the person doing the work, especially in certain special circumstances. To extend this work to people who in other circumstances, the time should be determined for someone with average skills and work under normal circumstances. This work is done by the rating factor. Following the work of moving objects appear reasonable projects. Once the basic movement patterns, designed and reasonably be determined without defects (methods engineering), as efficient and flawless production process is done automatically. Timing of the work is a step in work engineering. Timing of the application procedures and application of scientific principles to determine when an operation performed by a qualified worker in the efficiency is carried out (Zandin, 1994). To use this model, the information about the start time and finish time of each activity measured. Then by using data analysis & EXCEL software, the required parameters were estimated by using this information. The required parameters for simulation were studied. After ensuring about the accuracy of the generated simulation model in Arena Software, various scenarios were defined and also each of them were studied.

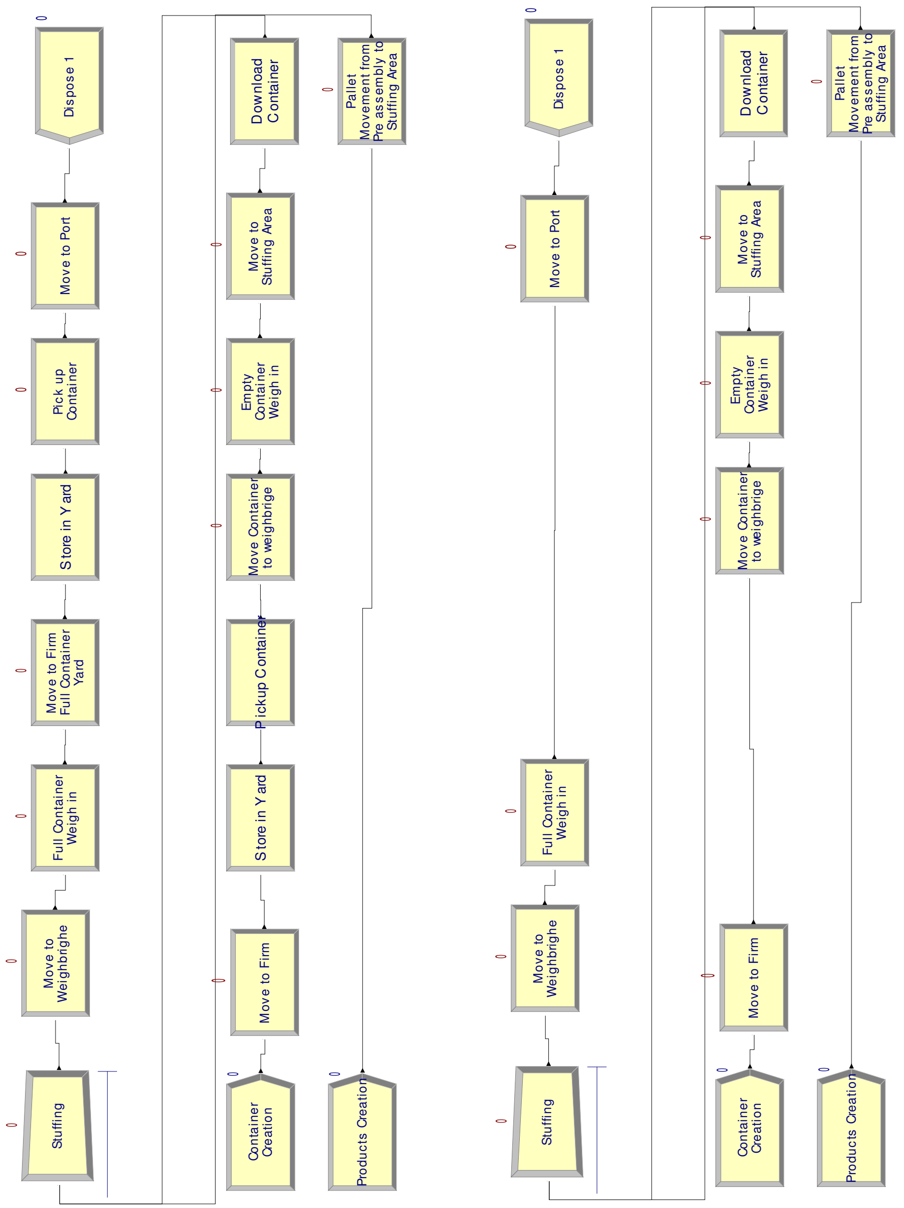

Figure 3. Scenario No 1

Figure 4. Scenario No 2

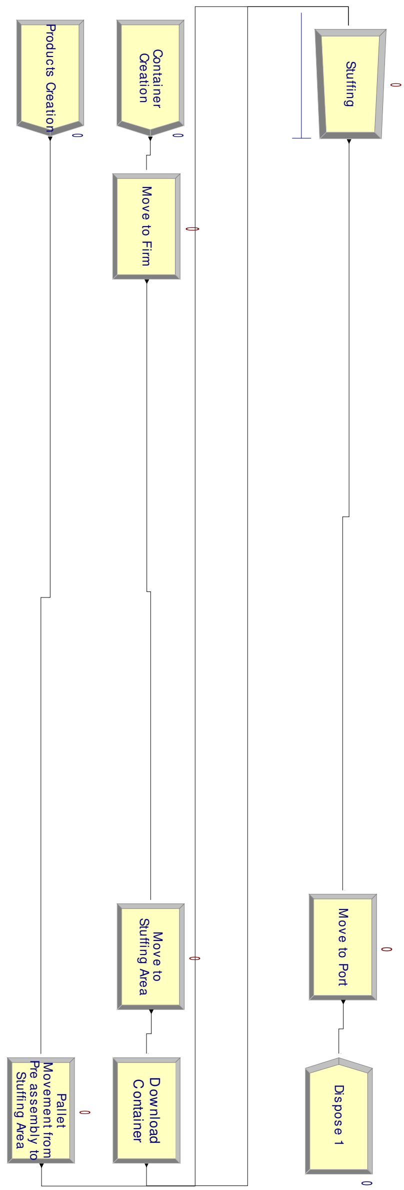

Figure 5. Scenario No 3

To reduce the number of trailers from 8 to 3 with installing new crane in stuffing area and removing the ramps.

To reduce the number of trailers from 8 to 3 with installing new crane in stuffing area and removing the ramps to move containers directly from/to port.

To reduce the number of trailers from 8 to 3 with installing new crane in stuffing area and removing the ramps to move containers directly from/to port and remove weighting process.

In the present case, the observed time at random times and also the amount of effectiveness and the costs make it completely dynamic, so that its effective quantitative analysis only happens with the help of the data analysis. For this reason, the data collected to evaluate different solutions for optimizing the scenarios and the analysis of their effects are inevitable. With the purpose of the modeling the case in this paper, simulation and VSM processes has been used. ARENA is one of the software, which is used in the simulation of the discrete systems and uses the SIMAN language (Rushton, *et al.*, 2006). There are the following main sections in the designed model.

Activity No 1: Pallet Movement from Pre Assembly to Ramps
Activity No 2: Container Movement inside firm
Activity No 3: Empty Container Movement outside firm
Activity No 4: Full Container Movement outside firm

Above section has been divided to more detail and according to the designed model, the required data were collected from the process of the stuffing and movement of containers. These data were collected for at least 62 periods for each cycle. The statistical analysis was performed on data, for each cycle.

4. Findings

According to data collection and simulation results, the costs and time analysis are calculated as follows:

Table 1. The Cost Analysis

Scenario No	Scenario Description	Cost-Benefit Analysis($)	ROI (Year)
Scenario No1	New Investment for crane purchase and installation	(5,000,000)	2.78
	Saving Movement Payment (per year)	1,800,000	
Scenario No2	New Investment for crane purchase and installation	(5,000,000)	1.57
	Saving Movement Payment (per year)	1,800,000	
	No loading and unloading in firm Container yard	1,387,755	
Scenario No3	New Investment for crane purchase and installation	(5,000,000)	1.61
	Saving Movement Payment (per year)	1,800,000	
	No loading and unloading in firm Container yard	1,387,755	
	Remove weighting process	122,449	

The Cost Analysis

Table 2. The Time Analysis

Scenario No	Scenario Description	Time Analysis
Scenario No1	New Investment for crane purchase and installation	removing pre-assembly to firm container yard time
Scenario No2	New Investment for crane purchase and installation	removing pre-assembly to firm container yard time
	No loading and unloading in firm Container yard	remove loading and unloading time in firm CY
Scenario No3	New Investment for crane purchase and installation	removing pre-assembly to firm container yard time
	No loading and unloading in firm Container yard	remove loading and unloading time in firm CY
	Remove weighting process	removing movement for weight in time

Table 3. Scenarios Analysis

	Evaluation Criteria		
Scenarios	**Saving Time (%)**	**Saving Cost (%)**	**ROI (year)**
Basic Scenario	0.0%	0%	-
Scenario No1	0.8%	7%	2.78
Scenario No2	30.9%	11.8%	1.57
Scenario No3	35.7%	12.3%	1.57

By observing the above table and comparing the different scenarios, the following conclusions can be achieved:

Based on the results, the maximum saving time of the cycle is for scenario No 3, and the maximum amount of the saving cost is for scenarios No 3 as well, but from ROI perspective, there is no difference between 2nd and 3rd scenario and both of them are better than 1st scenario. Therefore, considering all evaluation criteria, the best scenario is scenario No 3.

5. Conclusion

In this paper, the process of loading, unloading and movement of the containers, in the firm has been studied. The aim of this study is to determine the maximum efficiency of process and movement equipment's and also to minimized the cost and time for this purpose. Simulation and VSM processes have been used to study this system regarding the complexities of the logistics processes. At the end by designing and implementing of model in ARENA software, the results of implemented simulation, by study of alternatives have been analyzed. Finally, current optimization leads to increase efficiency in the firm's logistics and reduction of approximately 12% of the logistics costs and 35% of process cycle time.

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