

# Material Handling, Inventory and Productivity Improvement *A Lean Six Sigma Approach Case Study*

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**Abstract:** This paper describes a two-step strategic-tactical Lean Six Sigma methodology as used by the author to improve productivity, enhance inventory and material handling management, and thus, reduce operational costs at “Down Town Press Inc.”, a commercial printing press located in New York State, USA. A close look at the company’s performance revealed a troubling picture with only 51 % utilization of personnel, nearly \$40,000 of invested capital underutilized annually, and an excess of monthly inventory costs of almost \$29,000. This study was conducted to help the company avoid a fatal bankruptcy and regain financial prosperity. First, a strategic Six Sigma DMAIC procedure approach is deployed to better understand the deep turmoil faced by Down Town Press Inc. Second, a more tactical Lean approach is applied to identify various wastes and propose a set of techniques, technologies and strategies to reduce or eliminate the identified wastes, and thus, reduce operational costs. The continuous improvement changes proposed at the conclusion of the study suggest a possible reduction of \$300,000 in yearly operational capital. Furthermore, with the implementation of the proposed Inventory Management integrated with a comprehensive Material Handling Management System, the study predicts a higher utilization of employees and, therefore, an increased productivity.

## 1 INTRODUCTION

Established in the late 1930s, Down Town Press Inc. is a family-owned downstate New York based company that has served and continues to serve the local industry and private businesses in printings by providing various customized items including calendars, check books, customized envelopes with company logos, and a variety of prints, journals, and pamphlets. To protect business privacy, the company’s real name, the exact physical location of its operations, and financial/ figures (turnovers) have been purposely altered and coded in most parts of the paper without losing the essence of the benefits generated by the study. Throughout years of successful operations, Down Town Press Inc. moved from the status of a small family owned factory to a medium-size company with operations spreading on a 100,000 square foot floor, three dozens of machines, approximately 120 employees, and more than 1,000 varieties of items in inventory on-hand. Due to the high increase of demand from local businesses, the company is now using the intuitive

software ERP to manage their daily activities and operations. Although the company realized some noticeable expansion due to the increase in volume and complexity of operations throughout time, the firm management style, however, had remained the same for the last decades. Down Town Press Inc. is still operating in the old fashion and traditional ways, with huge amounts of raw materials on the shelves. With one single family exclusively managing the facility by just and primarily focusing on the profits generated by the company, very little attention was paid to the deep and alarming decline of operating and/or performance indexes, until recently when the management realized that not only competition was establishing solid roots and stronger ramifications, but also the company’s profits were shrinking. With non-accurate or almost nonexistent forecasts on seasonal demands and a totally inexact information on the actual level of inventory on the shelves the company started experiencing difficulties in the daily management of operations, resulting in missing delivery promises, losing markets, hence, valuable customers. Down

Town Press Inc. requested the service of one of the authors to assess the problem and recommend possible immediate solutions.

## 2 OBSERVATIONS

A preliminary analysis of the firm using a strategic Six-Sigma DMAIC procedure revealed that the two areas mostly in need of improvement were the “Materials Handling” and the “Inventory Management” systems. Quantitative tests and communication with management and crew members on the floor revealed that the major problems in these two problematic areas were interlinked and self-compounding. Although diligently working all day long, material handling crew members had a very low effective utilization with a very poor accomplishment because of a lack of awareness of stock location and quantities on-hand. No real-time data is available to assist in locating stocks. Furthermore, there is no integration of the current enterprise resource planning system (ERP) and the materials handling system. As a result, work as done at the Down Town Press Inc. is not efficiently performed, and at the same time, a significant amount of money is lost and wasted in non-productivity while operating costs are exponentially increasing. In the next sections the paper describes the methodology and improvement models used to face and meet these challenges.

## 3 METHODOLOGY

The methodology adopted in this project is a two-step approach. First, in a strategic approach this study implements a thorough DMAIC strategy to properly define the problem and uncover the areas in need of improvement at Down Town Press Inc. and the extent of the remedial actions. Second, in a more tactical approach and using Lean techniques and tools, the study implements the solutions to the problems as identified in the first and strategic approach. The combination of DMAIC a powerful six sigma tool with some of the Lean techniques such as 5s, kanban, and kaizen has provided a sound analysis of the current situation and a set of remedial solutions that helped in designing a robust configuration of the overall facility and generate significant cost savings.

## 4 ANALYSIS AND IMPROVEMENT OF CURRENT SYSTEM

One of the most widely used Lean Six-Sigma improvement procedures is a model known as Define-Measure-Analyze-Improve-Control, popular under the acronym of DMAIC. This procedure is used when a project's goal can be accomplished by improving an existing product, process, or service,

### 4.1 First Step Strategic Approach: DMAIC Procedure Implementation

The DMAIC structure is a procedure established into five phases, each phase being the preparation to the next one(s) while using specific tools. In the next sections a short description of each phase is provided along with the specific actions and tools as they were used during their implementation under this study.

#### 4.1.1 Define

The purpose of *Define* phase for the improvement team is to clarify the goals and refine their understanding of the potential value of a project (George, 2002). The most important goals are obtained from the end user customers. This study obtained goals from direct communication with the management, shareholders, and employees. As mentioned earlier, it transpired from these communications with the workers and the management that the major goal of this project was to improve the material handling system as well as the inventory management in order to enhance the overall productivity level and gain some significant cost savings.

#### 4.1.2 Measure

The purpose of the “*Measure*” phase in DMAIC is to gather data that describes the nature and extent of the problem. During this phase the team establishes valid and reliable metrics to help monitor progress towards the goal(s) defined at the previous step. At Down Town Press Inc., this phase involved two steps:

First, gathering of quantitative data and in the areas of stock accuracy information, materials handling systems, and crew member productivity. A three-day time and motion study was conducted in order to survey three material handlers and their daily activities. Results from the three day time

study showed that the three crew members were only being effectively utilized an average of 51% of the day. The rest of the day was spent unproductively fighting with the system, looking for stock and searching through pick tickets. The monetary effects of this low productivity will be investigated later in this study.

Second, another study was conducted during an inventory cycle count, in which all the stock items that were incorrectly stored, or whose location was incorrect or unknown to the system were noted. Among these were some items found located in multiple locations while the system had them only in one location on file.

### 4.1.3 Analyze

The goal of the “Analyze” phase in DMAIC is to interpret the data and/or information in order to establish the cause-and-effect relationships that produce the flaws in the system. During the “Analyze” phase the purpose is to develop knowledge that will help a Lean Six Sigma team to implement the countermeasures that address the underlying causes of problems in the next Improve phase of the DMAIC procedure (George 2002).

For this study and for few selected items, three major analyses were performed including a time study analysis, an ABC Analysis, and a run-out time inventory analysis. Results from this three-axis study showed that nearly 20% of the inventory counted had either location or quantity errors. A plant-wide study would have surely shown an even greater deviation.

This study helped justify the need for improvement while revealing problems such as inaccurate stock information, poorly managed and unorganized warehouse, low personnel productivity, excessive inventory levels.

The ABC analysis led to the classification of items according to their volume in stock and value in monetary terms. The reader is referred to Heizer *et al.* (2013) for details about the concepts of run-out inventory, EOQ, re-order point, ABC analysis, and other operations management terminology and concepts, and to Meyers and Stewart (2002) for details on motion and time study for lean implementation

The run-out analysis has been conducted to identify which items would run out first and what should be the optimal sequence of using them while minimizing the inventory costs. Furthermore, using the Economical Order Quantity (EOQ) model, re-order point and optimal order quantities were

derived for the most strategic items in the shop.

The results of the ABC analysis based on monthly sales records and the subsequent run-out and time analysis studies are represented in the following graphs. Figure 1 represents the Pareto chart used to conduct the ABC classification of the top items in stock by on-hand quantity. Note that the item 61004 70 # copy paper, representing 20% accounted for the highest level of inventory on-hand. This item (61004 70#) as well as both offset texts item 801210000 50# and item 100960 60#, fourth and seventh on the ABC Pareto classification, respectively, are items set aside for a wholesale job of calendars. The ABC analysis is based on Pareto’s rule of 20/80.

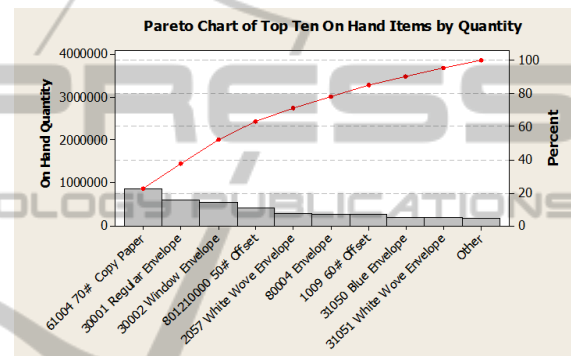


Figure 1: ABC Pareto Chart of the Top Ten On Hand Inventory Items by Quantity.

The next highest items in volume were the envelope stocks (item 30001).

In order to keep the analysis simple, this study decided to only track these four envelope stocks (second, third, fifth, and sixth on the Figure 1 of the Pareto ABC classification) because they are run on the same machine and in the same department.

This study anticipated that after a thorough analysis of inventory on-hand and material handling the results derived for these four items would be indicative of the general situation in the factory and, therefore, could be used for the overall improvement of the entire system.

The value of the Pareto principle for a practitioner is that it reminds him/her to focus on the 20 percent that matters. The reader is referred to authors such as Heizer *et al.* (2013) and Krajcski *et al.*(2013) for more complete details and examples on ABC classification and run-out time inventory management.

The derived classification consists of grouping items according to annual sales volume, in an attempt to identify the small number of items that will account for most of the annual sales volume and

that would be the most important to control for an effective inventory management, following the 20/80 rule of the Pareto theory.

In this study, after analysis the above targeted four items were classified into three categories: A - outstandingly important; B - of average importance; C - relatively unimportant as a basis for a control scheme. In theory, each category can and should sometimes be handled in a different way, with more attention being devoted to category A, more or less to B, and less to C.

Figure 2 shows the revised Pareto with the four selected/coded items. Figure 3 shows the results of the inventory analysis comparing the monthly demand and the inventory on-hand at the month's end. It is important to note that both coded items 30001 and 30002 end of month inventory on-hand at represent more than twice the forecasted monthly demand and required amount.

Figure 4 shows the results of the run-out time analysis that was conducted after daily and weekly demands were calculated. The various run-out times for the selected items are compared to the respective supplier's lead time.

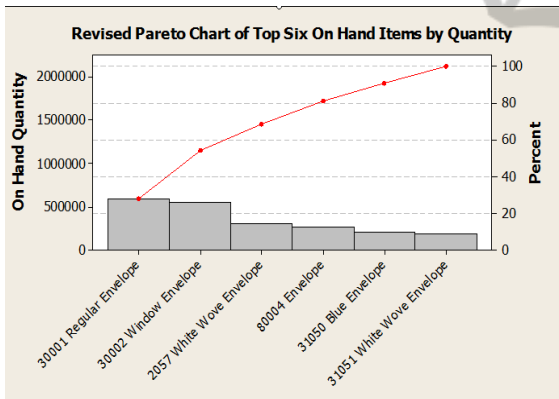


Figure 2: Pareto Chart for Selected Items Processed at the Same Equipment.

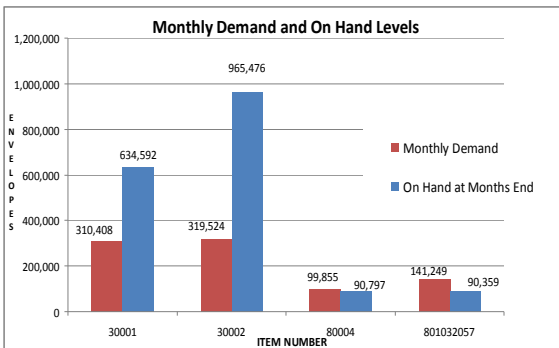


Figure 3: Monthly Demand vs. On hand Inventory Levels for Four Selected Coded Items.

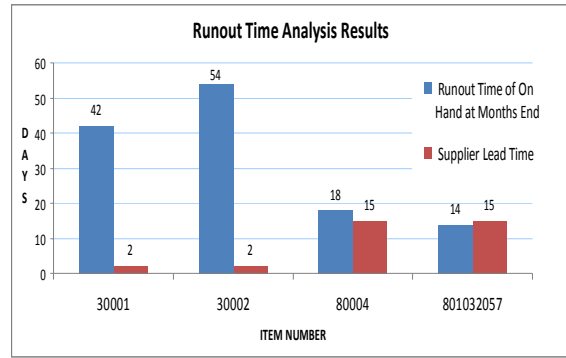


Figure 4: Run-out Time in Days vs. Supplier Lead Time for Four Selected Coded Items.

It is important to note the lack of correlation between the suppliers' lead times and the number of days covered by the stock on-hand. Coded items 30001 and 30002 have over 40 days worth of stock with a lead time of just only 2 days. A simple implementation of a Just-In-Time structure would reduce the inventory level and the associated holding costs. To the contrary, both items 80004 and 801032057 are dangerously close to the reorder point threshold as shown in Figure 4.

Based on the results accumulated so far in this study, it becomes appropriate at this stage of analysis to initiate the second step of the approach used in this study and already deploy some of the Lean tactical tools in the rest of the DMAIC phases.

## 4.2 Second Step Tactical Approach: Utilization of Lean Tools and Techniques

As said earlier, a combination of Lean and Six Sigma tools were used in order to make this study powerful and robust. In a first step Six Sigma tools were deployed through a DMAIC procedure to Define the problem, Measure its extent, and Identify (Analyze) the causes. Now that the causes are known and the cause-and-effect relationships established, the study moves to the second step of its approach, the use of Lean tools to Improve and Control the system.

### 4.2.1 Improve

In the "Improve" phase of a DMAIC procedure the goal is to develop solutions targeted at the confirmed causes as identified in the Analyze phase (George 2002). Based upon the findings from the several analyses conducted throughout this study it became clear that the gap between the current ERP software,



the materials handling system and the crew needs to be bridged. The “Lean theory” advocates the identification of waste also known “muda” in Japanese, followed by its reduction and or complete elimination.

In the case of Down Town Press Inc. the two areas of waste generation have been identified as material handling and inventory management. In order to reduce or eliminate this waste, this study recommended two powerful lean tools, namely:

- i) An electronic “kanban”.
- ii) A warehouse-wide 5S.

“Kanban” is a visual signaling system based on cards, plastic markers, small balls or an empty bin or area of the floor or software-based signal that is used to trigger an efficiency improving action.

5S is a methodology for workplace housekeeping based on the following steps: Sorting, Setting in order, cleaning (Shining), Standardizing and Sustaining the discipline while keeping and emphasizing on Safety. This tool needs to be implemented as an inventory tool in order to maintain the inventory on-hand for selected items at the right amount as determined by the EOQ approach used in the Analyze phase. This process shall be conducted to organize stock, minimize empty travels, stock search times and increase user safety. The reader is referred to Heizer *et al.* (2013), Tshibangu *et al.* (2008), Krajieski *et al.* (2013) for specific details on Lean tools and techniques including kanban and 5S.

This study has also recommended new technology including Forklift Fleet Management System (FFMS) to be implemented in combination with the techniques listed above. Among others, the use of three VX7 full screen vehicle mounted computers (VMC) on forklifts to track the inventory on-hand and update the ERP in real time. This solution requires the current ERP software to interact with a full-size high resolution screen, barcode scanning ability, and wireless connectivity across the plant. Figure 5 shows the projected working capital savings for each of the four selected stock items in case the suggested Lean tools and inventory forecasting techniques are implemented. A rather large 20% cushion was used to allow for variations in demand and possible supplier issues.

As the DMAIC procedure was being deployed and implemented in this study, it became evident that the “Analyze” phase was instrumental in finding the root causes of all the problems, including: stock information inaccuracy, low crew member productivity and, excessive on-hand inventory levels. Further investigation of the productivity issue

revealed that the main factors impairing productivity achievement include:

- i) Lack of procedures, organization, and accountability; No interface communication or interaction between the ERP software, the material handling system and the crew members on the floor.

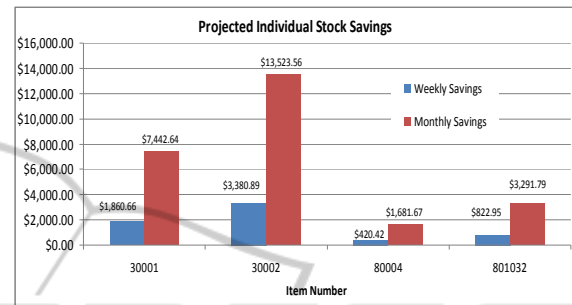


Figure 5: Projected Savings on four Selected Coded Items.

#### 4.2.2 Control

The purpose of the last phase “Control” of a full DMAIC procedure is to make sure that the gains made throughout the other phases of the procedure are preserved (sustained), until and unless new knowledge and data show that there is an even better way to operate the process (George, 2003).

For this study, in order to make sure that the improvements/gains can be sustained, the following actions were recommended and must be taken:

- i) Random cycle counts and location audits shall be conducted often to make sure that the physical count and location are in accordance with the ERP records. Cycle counts shall also be used to test the effectiveness of the proposed kanban system.
- ii) Regular meetings and frequent training sessions should be held to discuss problems and define corrective actions, assign tasks, and enhance operators’ skills and/or abilities through internal training sessions for example.
- iii) Usage and applications of forecasting methods to find the various EOQs and validate kanban signal points.

iv) Time and productivity studies need to be performed regularly to make sure operators are being utilized at the maximum of their potentials.

v) Kaizen sessions need to be implemented. Kaizen is a philosophy promoting teamwork, sharing of ideas and continuous improvement that eliminates waste. Figure 6 shows the projected total savings of working capital if the kanban signaling system and forecasting techniques for inventory management are implemented on all four selected coded items.

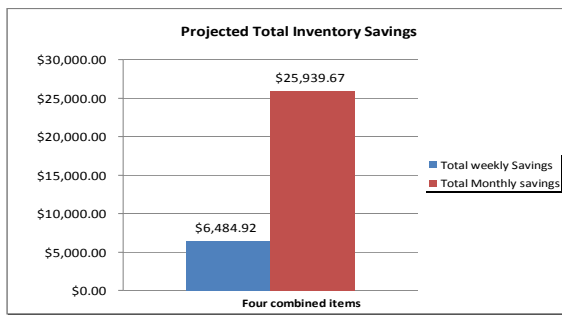


Figure 6: Anticipated Savings From Better Inventory Management.

## 5 HYPOTETHICAL EXAMPLE OF SAVINGS GENERATED FROM IMPLEMENTING FLEET MANAGEMENT SYSTEM

This section provides samples of engineering economic calculations to illustrate how additional savings could also be generated through the implementation of a wireless Forklift Fleet Management System (FFMS). Trucks and other powered industrial vehicles are essential equipment to the operation of warehouses and other storage buildings.

This equipment, which includes forklifts, tow motors, pallet jacks (walking or riding), and tractors (or spotters) is used to move goods throughout the building, loading docks, and trailer parking areas.

The efficient management of these important resources has been very limited. Due to the size and complexity of the facilities, and the unsupervised nature of the work of the operators (like the case at the Down Town Press Inc.) it becomes increasingly difficult to keep track of where each piece of equipment is located and how much work is actually being performed.

Additionally, use by unauthorized personnel, as well as unsafe use by authorized operators, has led to accidents and injuries, as well as impacts, damage goods and equipment or structures.

Currently, there is no wireless forklift fleet management system at Down Town Press Inc. The integration of such a technology in the operation of business would assist in the monitoring of the operations and maintenance of the vehicles and batteries. The lack of a comprehensive utilization data had caused Down Town Press Inc. to continue to purchase and maintain more pieces of equipment

than were required to support the operation.

The current state of operations at Down Town Press Inc. also lacks integrated logistic support capability. Preventative maintenance (PM) schedules are based on tasks being performed every certain number of days, weeks, or months. This approach completely ignores how much each piece of equipment is actually run, creating a situation where work-hours are spent on performing unnecessary maintenance when other tasks could be finished with those resources.

The proposed comprehensive FFMS will provide a variety of useful information to plant supervision, including the following:

- Current (approximated) location of each material handling vehicle
- Assurance that only qualified, trained operators have access to vehicle
- Assurance that the equipment is not operated until a pre shift safety checklist has been completed
- Measurement of the amount of time that operator is logged onto vehicle
- Measurement of the amount of time that the vehicle is in motion
- Assurance that in the event of a collision of significant enough impact to result in injury or damage the goods or equipment, there is confirmation on the identity of the operator who was responsible for the event.

In order to provide this information each piece of material handling will be modified with a transceiver, sensors, and an operator interface panel. The system will be used to verify operator authorization, will guide the operator through a pre-shift safety checklist, and will collect data on log and movement time.

The system will also provide estimated location information and will record any impact events. To provide vehicle tracking capability, a number of transceiver gateways will be installed throughout the facility. These units will link the vehicles to computers which can be accessed by supervisors or management personnel. The flow of information that will be received through these computers can be used to manage the daily operation of the vehicles, as well as to make future decisions concerning the fleet. In the calculations presented in Tables 1 and 2 below show that significant savings are generated from a hypothetical situation of an initial fleet of 50 vehicles downsized to 45 (as a result of FFMS integration) during the course of one 8 hour-shift. This downsizing of 5 units from an initial 50 unit-

fleet represents a 10% fleet reduction. The proposed model assumes an hourly labor rate of \$20 for the handlers and \$25 for the maintenance crew. The inflation and discount rates are 1.90% and 7.00%, respectively. The annual material handlers' savings in cost is calculated to be \$228,800 while the maintenance crew, at 50 hours per vehicle per year will generate a saving of \$6,250 per year.

Under this model, with an initial capital investment of \$157,667 over a three year life (from 2014 to 2016), the Net Present Savings would be of \$279,357 with a Return On Investment (ROI) of 121.7%. These encouraging results could be extrapolated to the particular case of Down Town Press Inc. and lead to promising savings on operational cost

## 6 CONCLUSIONS: EXPECTED RESULTS AND PROJECTED IMPROVEMENTS

The total capital investment to install the proposed three vehicle mount computers (VMCs) on the forklifts is approximately \$15,400. The proposed equipment will lead to an impressive Return On Investment of 189%. The reduction of paper usage will be gradual and departmental. The first area to be targeted is the envelope presses in which the most waste is currently occurring. The use of pick lists for issuing stock will be reduced one stock item at a time to reduce the risk of complete system failure and to allow changes to procedures.

Additional savings would be generated by integrating a fleet management system that would subsequently reduce the fleet size as increased productivity will be generated through the other proposed changes. It has been proposed a gradual addition of the electronic transducers to the material handling equipment through FFMS as savings are generated from other areas. Initial investment could be in the range of \$157,667 for a fleet size of 50 vehicles including support and training.

At the time of completion of this paper, only a partial implementation of the proposed solutions was underway at slow pace, justified in part by temporary economical and financial issues at Down Town Press Inc. coupled with a level of uncertainty in the chaotic market exchange and a certain dose of fear and skepticism from the management.

However, the company management has recognized the merit and benefits of the study including i) an actual realization of an accurate real-

Table 1: Cash Flow Analysis of Hypothetical Implementation of Fleet Management.

Fleet Management System Cash Flow Analysis				
Hypothetical Case				
Inflation/Discount Factors:				
Inflation rate - Labor	1.9%			
Inflation rate - other	1.4%			
Discount rate	7.00%			
	0	1	2	Total
End of Year	2014	2015	2016	
Investment				
1. Hardware - Site	(\$100,000)			(\$100,000)
2. Installation Management	\$0			\$0
3. Hardware - Spares	(\$33,333)			(\$33,333)
4. Contracted site preparations	\$0			\$0
5. Shared Program Costs	(\$10,000)			(\$10,000)
Contingency (10%)	(\$14,333)			(\$14,333)
Total Capital Investment	(\$157,667)			(\$157,667)
Operating Variances				
	End of Year	2014	2015	2016
4. Manual Handler Labor savings		\$233,147	\$237,577	\$470,724
5. Maintenance labor savings		\$6,369	\$6,490	\$12,859
Total Operating Variances		\$239,516	\$244,067	\$483,583
Net Cash Flow (Undiscounted)	(\$157,667)	\$239,516	\$244,067	\$325,916
Discount Factor (@ 8.6%)	1.0000	0.9346	0.8734	
Discounted Cash Flow	(\$157,667)	\$223,847	\$213,177	\$279,357
Net present value @ 8.6%:	\$279,357			
Return on investment:	121.7%			

time stock information through the use of VMCs, ii) a more organized work floor as the result of 5S implementation, iii) an appropriate and accurate inventory tracking of stock levels due to the combination of forecasting models and kanban signals, iv) and a higher personnel productivity as a consequence of manpower utilization improvement and enhanced skills and motivation from training.

This study shows a possible reduction of \$300,000 in the yearly operating capital and the perspective of an extremely high and appealing cost saving from material handling, due to a proposed 10% reduction of the current fleet size as the result of the integration of a comprehensive fleet management system as depicted in the scenarios in Tables 1 and 2.

Table 2: Potential Savings Under Fleet Proposed 10% Fleet Reduction 50 Vehicles vs. 45.

Example of Productivity Enhancement Using Forklift Fleet Management System (FFMS)						
Inventory	Current	Proposed	Change			
Forklifts	22	20	-2			
Riding Jacks	28	25	-3			
TOTALS	50	45	-5			
					Days/Year:	288
Material Handler Staffing	Current	Proposed	Change	Hours	FY14 Rate	Daily Savings
8 hour Shift	0	0	0	8	\$20.00	\$160
Total	50	45	-5	-40		-\$600
						\$228,800
Maintenance Savings	Current MHE Count	Proposed	Change	Hours	FY14 Rate	Annual Savings
At 50 hrs per unit per year	50	45	-5	-250	\$25.00	\$6,250

It worth it to note that this improvement and the subsequently derived monetary savings were achieved by solely considering four items and by maintaining them at the right stock level in a factory that contains thousands of such items. If, in addition,

similar improvement could be generated from the rest of items and the integration of a comprehensive fleet management system (FFMS), the possibility for savings and continuous business improvement through Lean Six Sigma is seemingly endless as evidently displayed in this study.

## REFERENCES

- George, M. (2002-3). *Lean Six Sigma: Combining Six Sigma Quality with Lean Speed*, McGraw-Hill.
- Heizer, J. and Render, B. (2013). *Principles of Operations Management, 9<sup>th</sup> Edition*, Prentice Hall.
- Krajleski, Ritzman, and Malhotra (2013). *Operations Management, 9<sup>th</sup> Edition*, Prentice Hall.
- Meyers, F. E. and Stewart, J.R., (2002). *Motion and Time study for Lean Manufacturing, 3<sup>rd</sup> Edition*, Prentice Hall.
- Tshibangu, W. M. Anselm and Berlinski, Stephen(2012). *Productivity Improvement Through Facility Layout Redesign: A Lean Six-Sigma Case Study*. ICINCO 2012, Proceedings of the 11<sup>th</sup> International Conference on Informatics in Control, Automation and Robotics, Rome, Italy, July 28-31, 2012.

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