A Productivity Model Utilising a Work Study Approach for Performance Measurement

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(Received 10 January 2011; Revised 27 March 2011; Accepted 29 April 2011)

Abstract: The purpose of this paper is to develop, construct and monitor the use of a fully functional productivity model at Harsco Infrastructure West Indies Limited (Harsco), in order to measure performance of worker productivity with primary considerations in improving customer satisfaction. Initial studies were conducted by analysing previous similar models in terms of mathematical equations and formula. Careful studies of yard operations coupled with a comprehensive background knowledge of industrial engineering techniques led to the development of a conceptual model which ultimately led to a full productivity model construction. Findings suggest that with the implementation of a productivity model at Harsco, there would be a noted increase in worker productivity coupled with the essential ability to measure and capture this information to analyse for improvements. Yard layout, inventory and customer satisfaction would be opted for high levels of improvements in efficiency and efficacies. This study generated insightful information into operational performance at Harsco. It was clear that productivity represented the basis for formulating future policy initiatives at Harsco and as such, the technical, theoretical and practical attributes of the proposed productivity model could be transcended to other service and manufacturing organisations in Trinidad and Tobago.

Keywords: Productivity models, work study, standard time, optimisation, productivity, value

1. Introduction

The world in most recent times has been described as an inter-connected, inter-related, integrated and interactive working environment. Today’s turbulent business environment continuously demands products and services to be generated and fabricated in a much smaller time frame, than the time frames required in previous decades. This demand for products and services ultimately means that the industries that are dependent on obsolete software and procedures for the accomplishment of tasks would soon become outdated themselves. This recent nature of the business environment, implores for the development of automated systems for procedures, thereby allowing faster results and products for satisfying the customer’s needs.

Productivity and subsequently performance measurement has become more important and has been regarded as a prerequisite for continuous improvement (Kaydos, 1991). When focusing on the industrial, national, and international levels, many approaches have been designed by economists such as the total factor productivity (TFP), or Bureau of Labor Statistics (BLS) multifactor productivity techniques (Duke and Torres, 2005; Meyer and Harper, 2005; Tsai et al., 2006). One of the major challenges faced at Harsco at the advent of a productivity model within its working capacity was the inability of the workforce to adapt to this severe paradigm shift in their ideologies and mindsets. The use of delay surveys (Tucker et al., 1982) to establish causal factors of labour productivity has been common hitherto. Borcherding and Garner (1981), for instance, reported results of a longitudinal study, which employed the craftsmen questionnaire survey technique on over 1,000 carpenters, electricians and pipefitters. Other researchers (e.g., Olomolaiye et al. 1988, Zakeri et al., 1996 and Kaming et al. 1997) employed such surveys to investigate the work content factors influencing construction labour productivity in Nigeria, Iran and Indonesia respectively. Throughout these studies, material and tool unavailability, rework due to design changes, weather or poor workmanship, crew interference due to scheduling problems, craftsmen turnover and absenteeism were all recurrent problems that curtailed productivity. While it is outside the jurisdiction of this study to find solutions in understanding workforce perceptions of productivity, it would serve to be valuable in understanding some implications existent when implementing a productivity model.

It was widely believed, in the construction industry, that productivity exhibited a decline over the past few decades (Brisco 1988; Christian and Hachey, 1995). Later, some microeconomic studies reported the contrary (Allmon et al., 2000). Irrespective of productivity trends, a
relatively recent research cautioned against unreliability in labour productivity raw data and the uncertainties inherent in the methods used for its estimation and interpretation (Eddy and Peerapong, 2003). Though extensive research has been done on parameters influencing productivity, most have focused on determinants that have mid- or long-term impacts on labour productivity (AbouRizk et al., 2001; Crawford and Vogl, 2006; Lam et al., 2001; Moselhi et al., 1997; Thomas, 1992; Thomas and Zavrski, 1999). Considerably less number of studies have targeted individual; not multiple factors, that cause daily or short-term variations in productivity (Hancher and Abd-Elkhalek, 1998; Koehn and Brown, 1985; Thomas and Sakarcan, 1994; Sanders and Thomas, 1993; Mohamed, 2005). Harsco is primarily focused on servicing the construction sector of Trinidad and Tobago. As such, similar labour productivity problems were faced by this studied organisation.

Over two centuries ago, the term productivity was used in the Journal de l'Agriculture (Tangen, 2005). It has been applied in many different circumstances, particularly in relation to economic systems, at various levels of aggregation. Productivity is the ratio of what is produced by an operation of process to what is required to produce it, or put simply the ratio of actual output to input over a period of time. Inputs might include transforming and transformed resources (such as materials, equipment, customers and staff) and the outputs are goods and services (Schroeder, 1985; Slack et al., 2001).

Although the definition of productivity appears straightforward, for three major reasons dealing with it is difficult (Andersson, 1996; Fitzsimmons and Fitzsimmons, 1997; Witt and Witt 1989). First, the outputs are usually expressed in different forms to the inputs. Outputs are often measured in physical terms such as units (e.g. cars produced), tonnes (of paper), kilowatts (of electricity), or value (euros) for example. However the inputs are usually physically different and include measures of people (numbers, skills, hours worked or costs) or materials (tonnes and costs) for example. Second, the ratio by itself tells us little about performance. A ratio of 0.75 is of little value unless it is compared with previous time periods, or a benchmark, or the potential productivity of the operation. Third, many different ratios can be used (both financial and non-financial, that can be used to create productivity ratios). Total factor productivity (TFP) is the ratio of the total output of all products and services to the total resource inputs which can be disaggregated into separate product and service productivity, single factor productivity (SFP), e.g. the output of product X over the input resources for product X. Productivity combines the concepts of effectiveness and efficiency, where effectiveness is the degree to which end results are achieved to the required standard (Slack, 1997). Growth is a function of total factor productivity (TFP), which is the aggregation of partial productivities (Heap, 2007). This study focuses primarily on the concept of utilising a common factor for measuring productivity, i.e. standard time. The standard time of the repair processes is coherently utilised for measuring both inputs and outputs. This common factor ensures that the results are accurate since there are no mixes in the forms of either the inputs or the outputs, (inputs and outputs are of the same form – standard time).

Harsco is a world leading organisation and its core business activities include, the Rental of Equipment and services related to Concrete Shoring and Forming Systems, Scaffolding and Access Equipment, Cranes and Hoists, Energy, Construction and Industrial Equipment, Environmental Services and the selling and servicing of light and medium Construction Equipment. The company has contributed significantly towards many construction developments throughout Trinidad and Tobago (T&T). In order to meet the daily demands of the construction sector, Harsco embarked on the implementation of an automated productivity model with attempts to revamp the inefficient processes and replace them with highly efficient and effective processes.

2. Identifying Problems and Setting Objectives
Due to the numerous problems constantly faced by Harsco because of the inability to properly manage the yard resources in an efficient manner there aroused an inherent need for improving productivity. The major contributors have highlighted this need for a model to measure productivity. These include, for instance:

1) Poor measurement of time for repair of equipment.
2) No system for accurately measuring inventory of equipment.
3) Lack of focus on priority customer requests when repairing equipment.
4) Poor measure of availability of equipment in the rental ready yard.

There are two major resultant inefficiencies suffered by Harsco as a result of mismanagement of human resource, equipment and machinery in the yard. They are:

1) Late delivery of equipment to customer (i.e., customer dissatisfaction), and
2) High labour and material costs due to inefficiencies in repair processes and wastage of time.

The traditional flow of information from the customers throughout the company prior to the introduction of the optimised Productivity Model was one which was archaic and inefficient. Each stage of the process lacked the support of solid scientific proof that the methods of tracking equipment availability and the processes of repair were indeed efficient. Harsco recognised the need for improvements to the system in terms of inventory management and resource control. The objective of this study is therefore to introduce a higher level of thinking and working at Harsco in terms of developing a productivity-model conceptual design followed by the construction of this conceptual model into
defined parameters utilising the function of MS Excel. Once this productivity model is built in MS Excel, it is then launched in the yard over a three month period, where its functions are meticulously monitored and controlled, highlighting many practical adjustments that would be required in order to successfully measure, manage and capture all productivity outputs and percentages obtained from the yard on a daily basis.

3. The Study Approach and Method
The application of a work study (WS) approach can be applied to a variety of circumstances. It can be considered an overarching template which encompasses a broad scope of applications ranging from the design of a new plant, to the design of a new product, to the design of a new process, to the improvement of an existing process and even to the improvement of an existing workplace (Wikipedia, 2010). Wherever work is being done, the WS approach ensures that work is being done in the easiest, safest, and most productive way. Harsco underwent a transformational change from the utilisation of an obsolete, inefficient, ineffective and immeasurable productivity model, to a high performance, efficient, automated and measurable productivity model.

Harsco focuses primarily on providing rental services to construction contractors within the Construction Industry in T&T. They utilise one yard for storage of equipment and a workshop for repair activities of that equipment. They specialise in the rental of formwork and scaffolding type equipment. Due to the nature of the jobs that the equipment suffers, they return to the yard in a state which requires different levels of maintenance. The operation processes therefore target the repair of all equipment, coupled with the loading and off-loading processes of equipment on and off trucks in the yard. As such, the employees are segregated into sections, each with different roles and responsibilities. The WS approach constitutes the usage of various charts and analysis, so as to facilitate the accuracy in tracking sequential activities in the workplace.

The intervention of the WS approach allowed for the tracking and control of the actual time to repair equipment, and the utilisation of an automated approach for the verification of equipment availability. To make the transition from the obsolete Productivity model to a high performance model, an axiomatic gap needed to be bridged. The gap analysis of this endeavour is stipulated in Figure 1. In order to bridge the gap, there was a need to conjure and institutionalise automation and optimisation techniques. The use of industrial engineering (IE) tools and procedures and work study in particular would aid in the automation of various core processes in operations. Figure 1 also continues to explain the entire process involved in developing, constructing, adjusting the model in order to make it more applicable to the real world operations in the yard.

3. The Study Approach and Method

**Standard Time Calculations**
The Standard Time (ST) is a unit time value for completion of a work task as determined by the proper application of the appropriate work-measurement techniques (BNET, 2010). For the purpose of this study the standard time was calculated for each repair process using the following formula:

\[ ST = \text{Observed Time} \times (1 + \text{PFD}) \times \text{rating factor} \]

The observed time was found taking approximately 30 times to repair each type of equipment and finding the average. PFD is the acronym for Personal, Fatigue and Delay. This value represents allowances for personal life activities, fatigue during work and any other delays which may arise. The PFD allowance takes into account the working conditions. If the person must put on safety equipment before starting the task then this time must be accounted for. If the person must stand all day to perform his/her job then this will impact his/her fatigue.

The rating factor is a professional estimate as to the working pace of the worker during the time taking exercise, and is rated by an industrial engineer with experience in studies. A person working at a normal pace is rated at 100 percent, working faster than normal is rated at no percent or working slower than normal is rated at 80 percent. A professional perception of the worker’s skill level, health, and levels of motivation also constitutes to this rating factor estimate. These behavioural attributes are proficiently considered in the aforementioned standard time formula. It is important to note that the procedures set for taking standard times can and should always be analysed for improvements. The improvements to the actual standard times of processes intrinsically result in improvements in productivity. This also allows the company to maximise its labour and machinery outputs. The company needs to be certain that it is investing money in labour and receiving the best output possible on a daily basis.

4. Design of a Conceptual Model
**Systems Parameters Defined**
There are three systems parameters for the model that are defined below:

1) **Priority Requests** – Information collected from the commercial area on a timely basis, depicting all projects, (both tentative and defined).
2) **Availability of Equipment** – Accurate inventory control, (the manual productivity model requires an accurate measure of quantities to generate the production plan, which is a schedule of all the equipment to be repaired on a given day and the number of man hours required to achieve this goal).
3) **ST calculations** – Number of man hours required to repair equipment stipulated in the production plan, (priority items would be repaired first, then other equipment from the repair yard).
The key elements for controlling and monitoring inventory and human resources functions are determined below:

1) For Inventory Control - These include (a) Auditor to perform cyclic inventory checks, and (b) Improvement in inventory accuracy (may utilise a margin of error).

2) For Human Resource Control – The model (a) uses standard time calculations to determine the number of hours required to repair equipment on the Production Schedule generated by the model, and (b) requires proper control of attendance in the yard (i.e., highlights number of labourers required for repair processes).

**Elements of Production Schedule**

Several elements are identified for handling production schedule, these are:

1) The type of equipment to be repaired (i.e., segregated into different workshops);
2) The quantity of equipment to be repaired;
3) The type of repair (i.e., segregated into simple repairs and complicated repairs and depends on the degree of repair required);
4) The total standard time to repair equipment in each workshop (i.e., Man-Hours); and
5) The total number of human resources required for the repair of equipment in all workshops for that particular day.

**Performance Indicator Measurement**

In order to measure the performance, the model identifies three primary indicators below:

1) How is it measured? – Theoretical vs. Physical quantities and standard times.
2) Whom does it measure? – Each yard employee, each repair workshop, the entire operations department.

These indicators are measured on a daily basis. The percentage productivity of each workshop is calculated using the formula of calculating four secondary indicators. They are elaborated below:

1) **Workshop Productivity**

   \[
   \text{Workshop Productivity} = \frac{\text{Theoretical Standard Time of equipment produced}}{\text{Actual Time spent in the workshop during the day}}
   \]

   The actual time spent in the workshop during the day is obtained via a manual control, where the empirical data is recorded in the workshop during the day.

2) **Worker Productivity**

   \[
   \text{Worker Productivity} = \frac{\text{Real Productivity of workshop}}{\text{Productivity of workshop}}
   \]

   It is noted that Real Productivity of workshop equals to Actual hours spent in workshop \( x \) Productivity of workshop. The assumption here is that each man-hour that a worker spends in a workshop has a productivity value equal to the productivity of that workshop.

3) **Workshop Accomplishment**

   \[
   \text{Workshop Accomplishment} = \frac{\text{Actual quantity produced}}{\text{Theoretical quantities programmed}}
   \]

4) **Workshop Service level**

   \[
   \text{Workshop Service level} = \frac{\text{Standard Time of actual quantities produced}}{\text{Theoretical Standard Time for programmed priority quantity}}
   \]

**5. Considerations of the Model Development and Construction**

When the standard time for the repair of each type of equipment is calculated, this information would be the basis for the entire automation process. Knowledge of a precise time to repair any particular type of equipment implies that the total numbers of that equipment that could be repaired in one working day can now be accurately calculated (and not estimated). This information is essential since the right number of man-hours can be allocated to the repair of equipment in demand. The exact number of human resource required to repair the equipment is also determined. Therefore, now the control of the standard time and the attendance of workers in the yard are determined. The third control, inventory control, is essential since quantities of equipment need to be determined for realisation of availability and the non-availability of rental ready equipment. Rental ready equipment is equipment that has been cleaned and repaired and ready to be sent to the customer’s site. An accurate inventory would allow for the high performance system to identify the number and type of equipment that needs repair. At this juncture, it is clear to understand the importance of having and maintaining these control factors.

Figure 2 depicts the conceptual high performance productivity model (that was used to replace the obsolete model described earlier). By observing the cascade of information from the client to the dispatch of the rental-ready equipment from Harsco’s yard, certain optimising...
criteria had been introduced into the system. Customer requests are now entered into the productivity programme which directly links current inventory to the client’s request. Based on the inputs (including the request from the customer and the priority of the projects and the availability of the equipment in the rental ready yard), the model could generate a master plan schedule of production for yard operations.

Figure 2. A conceptual model of attaining high performance productivity

The programme informs as to the availability and unavailability of equipment needed to meet the customer’s demand. Based on the standard time parameters, a stipulated time of repair and the number of human resources required are automatically determined. This also allows operations to focus on the priority equipment repairs. However, the model would not work effectively for having high productivity in the workshop but low availability of equipment with high demand and utilisations. Therefore, its efficacy would rely significantly on how the company handles the existing communication barriers between its commercial department and operations department. With the proper installation of the new model, operations could inform the
commercial department as to the precise time for the client to receive the equipment. It is anticipated that scheduling, logistics and customer satisfaction would have been improved.

The automated production schedule represents the resources and times required to complete repair activities. Therefore, the information can be used to measure the productivity of each employee. This allows Harsco the control of measuring performance of human resource. The calculations of overall productivity of the yard can be done with the information generated. Analysis of productivity allows for imperative decisions to be made regarding supervisor competencies and human resources requirements. Indicators are automatically generated from the model in the form of graphs and charts, which demonstrate the user-friendly idiosyncrasy of the model. The end product is an automated systems approach for all yard processes, (in terms of the equipment and tools required) that effectively accomplishes the task in the stipulated standard time prescribed.

A major concern regarding the implementation of a productivity model is the potential sacrifice in the quality and reliability of the repairs performed on the equipment. To combat this risk an additional procedure was devised for the auditor in the yard. This responsibility included an audit verification inspection to ensure that all repairs were in accordance to the specifications of the “Rental Ready” product. Before the equipment is moved from the workshop to the “Rental Ready” yard, this inspection is conducted by the yard auditor. Statistical information is collected and the results are analysed and presented in monthly presentations with the Director of Operations for Harsco. With this quality control in place, operations can ascertain that the improved levels of productivity would not encourage a decrease in the quality of the “Rental Ready” equipment. Results thus far have demonstrated that the quality of all repaired equipment was in accordance to the specifications required, and has been maintained with the improved levels of productivity and optimisation processes in the yard.

6. Results

**Generation of Production schedule**

The primary purpose of having a productivity model operational within Harsco is to ensure that there is a proper control on human resources working in the workshop and the times that are required for the repair of each type of equipment in the yard. Table 1 shows the Production Schedule generated by the productivity model for the first day of its operation.

<table>
<thead>
<tr>
<th>Workshop</th>
<th>Equipment</th>
<th>Production Programme (Quantity)</th>
<th>Type of Repair 1</th>
<th>Priority Q1</th>
<th>Type of Repair 2</th>
<th>Priority Q2</th>
<th>HH Programme</th>
<th>HH Workshop</th>
<th>Operators for Workshop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symons Panels</td>
<td>Panel Symons 24&quot; x 8'</td>
<td>84</td>
<td>Patch</td>
<td>84</td>
<td>--</td>
<td>0</td>
<td>13:37:36</td>
<td>18:41:56</td>
<td>2.34</td>
</tr>
<tr>
<td>Symons Panels</td>
<td>Panel Symons 20&quot; x 8'</td>
<td>20</td>
<td>--</td>
<td>0</td>
<td>Patch</td>
<td>20</td>
<td>5:04:20</td>
<td>4:44:25</td>
<td>0.59</td>
</tr>
<tr>
<td>Symons Panels</td>
<td>Panel Symons 10&quot; x 6'</td>
<td>30</td>
<td>Patch</td>
<td>30</td>
<td>--</td>
<td>0</td>
<td>4:44:25</td>
<td>4:44:25</td>
<td>0.59</td>
</tr>
<tr>
<td>Cuplock</td>
<td>Horizontal 3 ft 11 in</td>
<td>3</td>
<td>Simple</td>
<td>3</td>
<td>--</td>
<td>0</td>
<td>0:04:17</td>
<td>9:35:01</td>
<td>1.2</td>
</tr>
<tr>
<td>Cuplock</td>
<td>Horizontal 4 ft 1 in</td>
<td>22</td>
<td>Simple</td>
<td>22</td>
<td>--</td>
<td>0</td>
<td>0:42:36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cuplock</td>
<td>Horizontal 5 ft 11 in</td>
<td>170</td>
<td>Simple</td>
<td>170</td>
<td>--</td>
<td>0</td>
<td>6:47:46</td>
<td>31:21:22</td>
<td>3.92</td>
</tr>
<tr>
<td>Cuplock</td>
<td>Horizontal 5 ft 3 in</td>
<td>126</td>
<td>Simple</td>
<td>126</td>
<td>--</td>
<td>0</td>
<td>2:00:22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cuplock</td>
<td>Vertical 9 ft 10 in</td>
<td>275</td>
<td>--</td>
<td>0</td>
<td>Simple</td>
<td>275</td>
<td>31:21:22</td>
<td></td>
<td>8.05</td>
</tr>
</tbody>
</table>

This Production Schedule is generated in the evening before so as to allow immediate start of work the following day. As can be seen, the workshops are identified together with the name of the equipment for the respective workshop. The “Production Programme (Quantity)” is the theoretical quantity of the equipment that would need to be repaired during the day. The “Type of repair” is also specified and there are two main types; simple repair and complicated repair. Complicated repair is further broken down into three different types of repair for certain equipment types. Different types of repairs have different standard times; therefore the right standard time must be used in the calculations. This is the importance of choosing the type of repair. “HH Programme” signifies the total theoretical standard time to complete the repairs of the stipulated quantities. “Operators for workshop” provides the number of workers required, based on the total standard times.
The Yard Supervisor is responsible for actual allocation of the human resources by name. The number of people would be allocated to do the specific tasks. The practical experience of the Yard Supervisor facilitates the efficient allocation of the right people to do each task. This is an example of the practical approach to the theoretical model. If the wrong people are put to do certain tasks, the productivity results at the end of the day would be affected.

**Calculations of %Productivity, %Accomplishment and %Service level**

A reasonable definition of productivity is: Productivity = Value/Time. By this definition, there are two primary ways of increasing productivity. These are:

1. Increase the value created.
2. Decrease the time required to create that value.

This definition can become intricate by including other factors like energy and resources, but for the sake of simplicity, time can be utilised for this calculation because in most case factors like energy and resources are reducible to time anyway. Time also makes it very easy to compare different levels of productivity, such as output per hour or per day.

Productivity can be described as completing actual work in accordance to the standard times. As such, a manual control of recording empirical data during the course of the day as to the location of the human resources within the various workshops must be attained. This is the basis for calculating % Productivity of the workshop and by extension the % productivity of each worker.

With regards to the operations at Harsco and the production schedule, accomplishment can be described as the actual quantities of equipment repaired at the end of the day compared to the theoretical quantities programmed by the productivity model. A workshop can be very productive; however it can have a low % Accomplishment. This result depends on the length of time that a worker spends in the workshop.

Service to customers/clients is of the utmost importance for any service provider. Time is of the essence for delivery of any and all items. With respect to Harsco’s operations and their commitment to customers, Service Level can be described as the equipment that is repaired based on the customer’s request. These requests are priority and should be made preferential for repair as opposed to the repair of other equipment that is not priority. There are, however, different levels of priority; the most important ones should however always be on the front burner for repair.

These three indicators are very important for measuring performance in yard operations. They each identify opportunity areas depending on their respective results. Productivity results tell how productive the human resource is while working in the workshop. Based on the interpretation of the initial findings, low productivity implies that the worker needs to be evaluated or the standard times need to be reviewed. Very high productivity may call for the need to review the standard time for the process. Accomplishment gives a clear idea to management and the commercial department, that operations are repairing the right quantities of the right equipment and Service Level shows the commercial area that operations are repairing the quantities specific for the client so as to ensure that the equipment is rental ready when the client comes to the yard for collection.

The study focuses on the actual empirical results obtained for the first month in operation of the productivity model. As can be seen from Figure 3, the majority of the month experienced a productivity of greater than 100%, even though the %accomplishment and %service level were low.

![Figure 3. Daily results %Productivity, Accomplishment and Service Level for July 2010](image-url)
This implies that every hour a worker spent in the workshop was productive; however the workers would have needed to spend more time in the workshop in order to complete the programmed, theoretical, quantities, (which would have allowed for a 100% accomplishment and service level). Due to other more critical activities in the yard, workers had to be moved from workshop processes at various intervals during the day. This is another application of the “real world” practical concept versus the theoretical concept (Christensen and Raynor, 2003; Technopreneurship, 2007). It is noted that the extremely high % productivity can be the result of many factors, which are beyond the scope of this paper.

**Productivity of each worker**
The productivity of each worker is dependent on the workshop that each worker works in since the %productivity of the workshop is used to calculate the %productivity of each worker. An actual case of the calculation of the %productivity of the workers in the workshop (as at 7th July, 2010) is shown in Figure 4.

![General % Productivity of Labour](image1)

**Figure 4. General %Productivity of Labour**

**Improvements to customer satisfaction**
An important indicator that measures an important beneficial outcome of the productivity model is the “On Time In Full” (OTIF) indicator. This indicator gives a distinctive idea as to the satisfaction of Harsco’s clients pertinent to them receiving all the required equipment on time, (on or before the requirement date stipulated), and in full, (receipt of all the equipment requested for the project). The situation of “in full” is essential since improvements to this indicator axiomatically imply that there is an improvement to inventory control. The productivity model heavily enables this feature of inventory control and inventory management. Figure 5 depicts a record of OTIF indicator for 2009 and 2010 (up to July) at Harsco.

![OTIF Indicator](image2)

**Figure 5. OTIF Indicator at Harsco, 2009-2010**
It is shown that the months of June and July 2010 both experienced an OTIF response of 100% at Harsco. June experienced this unprecedented result because the controls for the productivity model were already being implemented, i.e. inventory control and management together with improvements to attendance and punctuality, before the actual launch of the model in the yard. July commenced the use of the model in the yard and the OTIF results for this month also showed the value of 100%. It is anticipated that 100% would be the resultant from this month onwards, unless there are extreme cases which demonstrate otherwise.

7. Discussion
The transition from the obsolete productivity model to the high performance productivity model came at a time when business was expanding and demands were vehemently shattering the commercial department. The abundant need for efficient and accurate processes in the yard was the call. Unlike minor imperceptible changes experienced before within the organisation, this transformation called for a company-wide cultural and behavioural shift. With the introduction of a number of newly implemented controls, the definition of the role of a yard auditor, discipline from the Yard Supervisor and effective technical IE competencies from the Operations Supervisor had to be demonstrated by practice.

The productivity model has been operational for the past seven months within the organisation and the indicators produced as the months elapsed showed signs of significant progress and improvements. Figure 6 shows the results after the first five months of operation within the working capacity of Harsco.

The initial month showed a lot of variances in the results since the highly theoretical model had to be adjusted daily to make the model more pragmatic. Customer satisfaction showed an initial steady increase followed by consistent high performance ratings since equipment are delivered on time and in full. Customer waiting time (in terms of the time spent waiting for trucks to be loaded or off-loaded) was reduced, which also enhances and promotes customer satisfaction.

“General productivity” signifies the productivity of the workshops and primarily the productivity of the labourers working in the workshops. “Commercial demand met” signifies the service level to the customer. This is a very important indicator that can effectively measure, to a great detail, customer satisfaction. Practical adjustments were done with this indicator so as to capture real world concepts. “Daily program met” signifies the level of conformance to the repair quantities programmed to be repaired on a daily basis. These quantities include both priority repairs as well as non-priority repairs. It is important to note, however, that the “commercial demand met” indicator is of greater value to management than the “daily program met” indicator, since the former ensures customer satisfaction and customer success.

There are several indicators to measure and track progress of all the areas in operations, from the determination of whether deliveries are on time and in full to the distribution of resources on a daily basis, and even extends to forklift utilisations and safety practises. These indicators present to management, a clear idea of the
efficiency in productivity practised with the adoption of and adaptation to the high performance productivity model. The working time of the model is currently small within the organisation, however the initial results have shown the potential application and capability of the model as evidence in the analysis of indicators before its implementation, during its construction and the couple months that followed.

As mentioned earlier in the study, the productivity model had been transformed from a highly theoretical model to one which was more pragmatic towards user-friendliness. Some of the criteria include:

1) The fact that customer requests had varying levels of priority (e.g., a project can be a low priority today and a very high priority tomorrow). The model must be able to combat this change in the highly dynamic local construction sector.

2) The concept that it is easier to control the “repair equipment” inventory to an accuracy of 100% (since the quantities of equipment are much smaller) and the monthly spot checks on all types of equipment would eventually allow Harsco to have and maintain an accurate “rental ready equipment” inventory.

3) The fact that workers would not be working in their respective workshops for the entire time stipulated in the Production Schedule. This may be a result of high levels of other essential activities in the yard, which would require these human resources. The measurement of productivity therefore, has to be managed in a careful manner so as to ensure that measurements are accurately made of the productivity of each employee based on the actual time spent in the workshop.

These three criteria prompted for adjustments to be made to the model. The final current model can now focus on the “real world” and gives results based on what is actually happening as information is transferred from the commercial department to the operations department, on a daily basis. The contributions of this optimisation approach would enable Harsco to prosper, with higher levels of worker productivity, attendance and quality. Some of the major contributions of this model to this hosted organisation include:

1) Promoting an increase in customer satisfaction.
2) Bridging existing gaps between commercial and operations department in terms of improved communication channels and knowledge transfer, (allows for better knowledge management procedures).
3) Allowing a complete measure of all repair activities and processes in the yard.
4) Precise indications of the number of workers required to work in the yard can now be determined.
5) Precise methods for calculating worker and workshop productivity and accurately measuring whether the commercial demand and daily demands were met, on a daily basis.
6) Improved inventory control and inventory management.
7) Improved human resource control and management, and
8) Cost savings in the yard measured in terms of man hours that result from improved productivity, (continuously improving the standard times of activities would continuously reduce cost in the yard).

One project which has promoted and implicitly forced the organisation to improve quality and efficiency is the development of the productivity model. This tool has integrated the departments of operations, commercial and credit and collections, to work in a more efficient manner. The model has undoubtedly added value to the operations department and by extension the entire operation at Harsco.

Currently, analysis is being conducted at Harsco to measure the savings in operation cost, with the advent of the productivity model in the yard. A project is on the way to improve the standard time values by reducing movements and eliminating unnecessary activities within the process. This reduction in the standard time values relates to an astounding implicit savings in yard operations. It is anticipated that by reducing the standard time values for one type of equipment alone, Symons, Harsco has the potential to save TT$142,850.00 annually. Figure 7 displays these results. It is important to note that these saving are specifically for Symons panels, there are other types of equipment which have the potential to contribute in cost savings when their standard times are also optimised.

Figure 7. Projected Savings in cost for 1 year (Symons Panels)

Other specific areas in the operation have also contributed to reductions in yard operational costs such as:

1) Classification of equipment immediately after a return to the yard – TT$38,875.00 (after 5 months).
2) Reduction in yard consumables costs – TT$1000.00
3) Reduction in labour cost – TT$14,400 per month.

Initially there were 14 labourers working in the yard, however, analysis of work functions confirmed that 9 workers are required. As such the average attendance per month in the yard is now 9.

This productivity model implementation now has effects on the organisation’s mission strategy, it promotes training, an efficient redesign of job responsibilities, it promotes interface relationships amongst departments, and it enables the ability to measure performance and promotes the use of information and database systems. By amalgamating the many different functions of the departments, the concept of process management is realised. The organisational culture has drastically improved and this culture has promoted continuous improvements. Measurements and indicators dictate that customer success has improved over the past few months and the role of feedback is endorsed and practised by everyone within the organisation.

8. Future work

The productivity model has thus far shown exceptional results in optimisation of processes. One possibility is to continuously improve productivity within the yard by continuously revising the standard time of processes. By analysing the processes and the resources required, reductions can be determined that would reduce the standard time for the many processes. By reducing the standard time, productivity is improved and cost is consequently decreased. In fact, in recent times analysis is currently being conducted to improve the standard times of all processes. Projections of yearly savings in improving productivity are always a strong determinant for company success and frequently catch the eye of management. By utilising Pareto’s concept of the 80-20 rule, the top 20% of repair processes that contribute to 80% of the revenues at Harsco, has been improved. The results of such analysis are however, outside the scope of this study and would therefore not be elaborated.

A cost model is currently being developed for Harsco, which would be strategically merged to the productivity model which would give management results based on labour costs, cost of consumables, cost of equipment and other yard costs. All costs would then be measured and displayed cogently by cost indicators. Equipment profitability would then be able to be accurately measured and managed. Unit production cost, average rental months and unit revenues would be depicted on profitability indicators, thereby allowing management to make more informed decisions.

The actual time invested in the development of the model as a programme is negligible when compared to the output and contributions of such a model. The productivity model implementation focused on organisational structure and culture and involved planned organisational changes. The concept of productivity and methods of measuring it may exist in larger companies in the various sectors of energy, manufacturing and construction in Trinidad and Tobago. However, the techniques of WS approach by the heavy utilisation of standard time analysis must be inherent to any productivity model. In order to be productive, companies are completing the task in the best time possible, using the least resources possible, while ensuring that the processes exclude the activities that encourage wastage of time, space and energy. As time passes, productivity models can become prevalent within companies, especially those with similar operations to Harsco or the traditional manufacturing company structure. With time and a proper understanding of the operations of a company, together with the tools and knowledge of industrial engineering techniques, productivity models could be successfully implemented within local companies in T&T.

9. Conclusion

This study presented the irrefutable need for efficiency and optimisation within the working capacity of Harsco, with primary emphasis on the operations department. It depicted the evolution from an obsolete and dysfunctional productivity model to a high performance and functional model. A WS approach was adopted to create the bedrock of the model. A great deal of time was spent in order to collect primary data from yard operations, and to gain accurate results for calculations. Due to the fact that the accuracy and effectiveness of the entire productivity model was predicated on the competencies of the standard time and WS procedures, it was complimented with the ‘trial-and-error methodologies.

The study explored the importance of adopting and measuring a high performance productivity model for the purpose of achieving and enhancing productivity, attendance, punctuality, inventory accuracy and the overall performance of the operations department at Harsco. It examined the importance of a pragmatic approach to a theoretical concept, and identified elements of the transition from theoretical/ conceptual to practical and realistic. The study has demonstrated its potential success by stipulating actual empirical results from the first month in its operation within the working scope of Harsco. The model promoted the need to focus on organisational development and to ensure that existing communication barriers between the commercial department and operations were disintegrated, thereby allowing for effective communication. It is anticipated that the lessons learnt from Harsco and the contributions inherent to the advent of a productivity model, could be applied to other companies in T&T. Future work would investigate the determinants and factors governing the adoption of the productivity model and evaluate the efficiency of the model with companies in various
industry sectors within Trinidad and Tobago.

The completed model has been functional within Harsco for over six months and the determined success of this model has allowed the corporate offices in Costa Rica, the ability to comprehensively analyse the status of the yard in Trinidad. Combined efforts to improve local operations were now possible, since the results and indicators have promoted many changes in the Trinidad yard. In October 2010, this productivity model was implemented in Harsco Chile, due to its successes in Trinidad’s operation. It is anticipated that the model would soon be implemented in Harsco Mexico and other United States Harsco operations, in the near future. The lessons learnt from Harsco’s productivity model, utilising the WS approach, could be applied to other contracting firms in T&T.

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