Chapter –7

PERFORMANCE MEASUREMENT OF WAREHOUSE MANAGEMENT SYSTEM

All the previous chapters focussed on medium-sized manufacturing industry performance measurement. Usually, the medium-sized industries are the suppliers to large companies and they are expected to work for the mutual success of the complete chain. In order to be competitive, medium-sized industries operating in developing countries must be ready to adapt automated supply chain management models rapidly [8]. Warehousing plays a crucial role as it links manufacturer, supplier and customer. Efficiency of a warehouse determines the efficiency of the supply chain. In line with all these issues, an attempt is made to study the performance of manual warehouse and compare it with a warehouse adopting warehouse management system. Implementing WMS requires huge investment and hence cost justification is essential before implementation. Cost benefit analysis is done to justify the investment taking a case study.

7.1 Warehousing function

In a supply chain, warehousing function is very critical as it acts as a node in linking the material flows between the supplier and customer. Performance studies are a measure of analyzing the performance of a business in order to benchmark against the competition and explore the possibility to improve in order to gain competitive advantage. Warehousing function is very critical within any supply chain. If the products do not move seamlessly within supply chain business would face serious service related challenges. Hence, it is necessary to drive the performance of the warehouse through key performance indicators. The warehouse operations are unlike production as they are not repetitive, but a number of measures can be devised to help measure warehouse productivity.
7.2 Warehouse Performance Measures

Measuring warehouse metrics is critical for providing managers with a clear vision of potential issues and opportunities for improvements. Metrics are tied directly to the business strategy and operation’s success drives the financial results of the organization. If warehouses are going to contribute to be a source for adding value to the supply chain then they need to measure their performance with perfect metrics. Key objectives in designing warehouse operations include increasing productivity, reducing cycle time, and increasing accuracy [7]. There are number of reasons compelling warehousing logistics professionals to investigate productivity solutions. Dynamic fuel costs have professionals up and downstream in the supply chain scrambling to find cost-cutting measures and higher operating efficiencies. Large enterprises continue to seek to reduce the number of stocking locations and drive more productivity from the remaining distribution centers. Literature has shown that cost and space pressures outweigh the pressures to improve operations because of rising customer demands for faster and more tailored fulfillment. However, the best performing companies are focussed on winning in both these dimensions: by creating faster throughput and more workflow agility in their warehouses, they are able to satisfy customer demands while lowering logistics costs.

Many times these objectives may conflict with one another, because, a method that focusses on productivity may not provide a short enough cycle time or a method that focusses on accuracy may sacrifice productivity. Researchers and managers typically attempt to find a set of measures which collectively capture most, if not all, of the performance dimensions thought to be important, over both short- and long-term horizons.

The metrics for measuring performance in a warehouse fall into three main categories which includes, order fulfillment, inventory management and labor productivity. The various metrics for measuring the performance is as shown in the table 7.1
Table 7.1: Performance Metrics of a warehouse

<table>
<thead>
<tr>
<th>Category</th>
<th>Measure</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order fulfillment</td>
<td>On time delivery</td>
<td>Orders delivered on time per customer requested date.</td>
</tr>
<tr>
<td></td>
<td>Order fill rate</td>
<td>Orders filled completely on first shipment.</td>
</tr>
<tr>
<td></td>
<td>Order accuracy</td>
<td>Order picked, packed and shipped perfectly.</td>
</tr>
<tr>
<td></td>
<td>Line accuracy</td>
<td>Lines picked, packed and shipped perfectly.</td>
</tr>
<tr>
<td></td>
<td>Order cycle time</td>
<td>Time from order placement to shipment.</td>
</tr>
<tr>
<td></td>
<td>Perfect order completion</td>
<td>Orders delivered without changes, damage or invoice errors.</td>
</tr>
<tr>
<td>Inventory management measures</td>
<td>Inventory Accuracy</td>
<td>Actual inventory quantity to system-reported quantity.</td>
</tr>
<tr>
<td></td>
<td>Damaged inventory</td>
<td>Damage measure as a % of inventory value.</td>
</tr>
<tr>
<td></td>
<td>Storage utilization</td>
<td>Occupied space (square footage) as a % of storage capacity (square footage).</td>
</tr>
<tr>
<td></td>
<td>Dock to stock time</td>
<td>Avg. time from carrier arrival until product is available for order picking.</td>
</tr>
<tr>
<td></td>
<td>Inventory visibility</td>
<td>Time from physical receipt to customer service notice of availability.</td>
</tr>
<tr>
<td>Warehouse productivity</td>
<td>Orders per hour</td>
<td>Avg. number of orders picked and packed per person – hour.</td>
</tr>
<tr>
<td></td>
<td>Lines per hour</td>
<td>Avg. number of orders lines picked and packed per person – hour</td>
</tr>
<tr>
<td></td>
<td>Items per hour</td>
<td>Avg. number of orders items picked and packed per person – hour</td>
</tr>
<tr>
<td></td>
<td>Cost per order</td>
<td>Total warehousing costs – Fixed: space, utilities and depreciation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variable: labor / supplies</td>
</tr>
<tr>
<td></td>
<td>Cost as a % of sales</td>
<td>Total warehousing cost as a percent of total company sales.</td>
</tr>
</tbody>
</table>

7.3 Warehouse Management systems

It is necessary to allocate warehouse resources efficiently and effectively to enhance the productivity and reduce the operational costs of the warehouse [92]. Therefore, warehouse management systems (WMSs) have been developed for handling warehouse resources and monitoring warehouse operations. It is difficult to update
daily operations of inventory level, locations of forklifts and stock keeping units (SKUs) in real-time by using the bar-code-based or manual-based warehouse management systems. RFID technology is adopted to facilitate the collection and sharing of data in a warehouse.

A warehouse management system (WMS) is a database-driven computer application, to improve the efficiency of the warehouse by directing cutaways and to maintain accurate inventory by recording warehouse transactions. The systems also direct and optimize stock based on real-time information about the status of bin utilization. It often utilizes Auto ID Data Capture (AIDC) technology, such as barcode scanners, mobile computers, wireless LANs (Local Area Network) and potentially Radio-frequency identification (RFID) to efficiently monitor the flow of products. Once data has been collected, there is either batch synchronization with, or a real-time wireless transmission to a central database. The database can then provide useful reports about the status of goods in the warehouse.

The objective of a warehouse management system is to provide a set of computerized procedures to handle the receipt of stock and returns into a warehouse facility, manage the logical representation of the physical storage facilities (e.g. racking etc.), manage the stock within the facility and enable a seamless link to order processing and logistics management in order to pick, pack and ship product out of the facility.

The introduction of WMS for the company represents a significant investment that demands a great time (several months), requires excellent analysis of the current situation in the warehouse and warehouse operation for a specific period of time tuning the WMS. It is necessary at the outset to determine what benefits are got through the introduction of WMS. On the other hand the firm should be prepared to change the entire process and system storage. WMS implementation without changing processes show that it does not lead to cost savings or efficiency improvements, rather it will only reduce errors due to human factors [107].
7.3.1 Productivity Improvement tools of WMS

Barcode
A bar code is simply a series of stripes (usually black) on a light background (usually white) that can be scanned and read directly into a computer. They are interpreted virtually instantaneously and without errors by a bar code reading system. Bar codes are read through the reflectance and absorption of light. A light of a given wavelength is beamed and moved across a bar code at a consistent speed. The reflected light is measured with a photoreceptor, tuned to look for light of the given wavelength. The off- and- on (white and black) pattern of the bar code creates an electrical wave that is sent on to a computer chip called a “decoder.” The decoder then deciphers the signal into something the waiting computer understands. Imager and CCD (charge coupled device) bar code scanners read somewhat differently in that they “take a picture” of a bar code symbol, analyze it, and create a conditioned electronic signal that basically mimics that from the reader types.

Barcode technology is the best-known and most widely used method of Automatic Identification. Automatic identification or “Auto ID” encompasses the automatic recognition and recording of data, most commonly through the printing and reading of information encoded in barcodes thereby eliminating risk of human error.

Bar coding System requirements
1. The Bar Code Printer
Bar-code labels are printed using bar code label printers. These printers print labels much faster and are of higher quality than those printed using a conventional laser printer.

2. The Bar Code Label
These are labels that are first printed and then attached to an asset for its identification.

3. Scanning Equipment for Data Collection
The data collection phase occurs through the use of scanners that instantly and accurately read, capture and decipher the information contained in the bar code label. Scanners read information much faster and more reliably than humans can write or type thus, significantly reducing the likelihood of error.
4. Capturing the Data to an External Database

To be able to effectively use the codes, a database of some type is needed to relay and update information. A database can be as simple as an Excel file or an Access database.

Put to Light/ Pick to Light-Overview

In a “Pick to Light” system, lights guide operators to SKU locations where they select or 'pick' items from. In a “Put to Light” system, light modules direct operators to the correct location to sort or 'put' items into.

One of the most popular applications for “Put to Light” systems is sort batch picked products into individual orders. Batch picking is when multiple orders are picked during each pass through the warehouse, optimizing fulfilment operations where there are a high number of SKUs and long pick paths.

Downstream these products must be sorted into the appropriate orders. Traditionally carts travel to pack stations where items are manually sorted by reading pick tickets, shipping or other paper lists. This approach is slow and prone to mistakes.

If products feature bar code labels, then “Put to Light” system is faster and more accurate way to execute this sorting. With “Put to Light”, the operator simply grabs an item and scans the label with an RF unit. Lights illuminate at locations requiring that item, and the quantities needed to fill the order. The process is repeated until the orders are completed. The Put to light approach is extremely fast and accurate. The RF scan and lights increase sort rates and reduce reading errors.

“Pick to light” and “Put to Light” systems are the most cost-effective means of providing dramatic improvements in warehouse productivity and picking accuracy.

The pick to light, paperless solution increases the “Pick rate productivity”, accuracy and cost efficiency of this labour-intensive operation by reducing walk time, eliminating reading errors and simplifying the task throughout the pick process.
7.3.2 Benefits of implementing warehouse management system

The modern competitive environment has shown that redesigning the functionality of a warehouse can play a significant role in the value offerings a firm is capable of delivering. Most of the customer specific service offerings are physically performed in the warehousing environment. Therefore, paying attention to the customer needs should be an essential part of the warehouse planning and order fulfillment strategy. By implementing Warehouse Management system, investment returns to organizations may be separated into three categories:– tangible, intangible and customer mandates.

The tangible benefits are financially measurable and verifiable returns related directly to the investment. Non-tangible returns are more difficult to quantify, yet intuitively evident as potential benefits of an investment in a WMS. Customer mandates include Industry standards or government or customer requirements which may well drive a WMS implementation.

A WMS significantly reduces the paper component of warehouse operations as well as the costs associated with data entry by clerical personnel. Hence the number of staff involved in doing paper work reduces. Warehouse labor cost reduction is typically the major contributor of a WMS investment. Implementing WMS enables sales growth without the equivalent increase in warehouse people and equipment. WMS operations enable the use of best practices; e.g., fewer material “touches”, minimized lift truck deadheading, leading to the reduced total cost of labor (direct and indirect), facilities and equipment.

Implementing WMS reduces the cycle time and optimizes physical processes and ensures high traceability of information flows. This, in turn, results in better operational efficiency.

The establishment of metrics for auditing warehouse performance and assessment of WMS potential as a basis for investment justification should be the first step in any WMS project [108]. The identification of proper metrics and opportunities for improvement can be a preliminary justification to determine potential payback [109].
7.4 Case example

To analyze the benefits of implementing warehouse management system, a study was taken at a leading retail supply chain network, which has developed expertise in Supply Chain Management of consumer product categories such as Fashion, Food and General Merchandise in India.

The company operates from 60 strategically located hubs, servicing more than 2600 retail outlets spread across the length and breadth of India. Its network of facilities and specialized expertise enable it to manage more than 3 million SKUs. This requires 30 distinct supply chains to be managed simultaneously, each with their own specific requirements that require customized solutions.

Three warehouses in South India run by the group work with SAP and do not have a warehouse management system. An effort to improve the warehouse performance by validating the implementation of a WMS-run-warehouse to a Manual-run-warehouse was taken in 2 warehouses. It was an initiative to identify the problems faced in an existing WMS-run-warehouse and suggest improvements. The research aims to evaluate performance levels and enhance productivity of the manual warehouses by developing a WMS framework for them. It also evaluates and compares a WMS warehouse with a non-WMS warehouse.

Performance studies in Warehouse

The warehouse had a floor space of 30000 sq. ft and three dedicated vehicles which carry goods from the warehouse to the different stores. The warehouse receives goods from about 200 to 250 vendors from across the country. Currently the warehouse services 7 stores in Bangalore. Warehouse has 50 employees including 10 security personnel, 8 permanent employees and the rest being contract labourers. This warehouse handles both the goods coming from the vendors and the goods being returned to the vendors. Warehousing operations are similar for both types of transactions. A flow through process is used i.e. what comes into the warehouse goes out as is. Neither are the goods stored for long nor are the boxes opened and sorted. Discussed below in detail are the current warehousing practices being followed in this warehouse:
7.4.1 Existing system

Warehouses mainly do the part of handling warehouse operations. Product volume monitoring, placing orders to vendors, order management, dispatch orders and other such monitoring and decision making is done by the category team appointed to handle specific product types. A purchase order is first generated by the category team to the vendors. The purchase order also gives the deadline before which the order has to be completed. Vendor on receiving the order, process it and when the order is ready for dispatch intimates the category team. All these transactions are done in SAP (an ERP). On knowing that order is ready category team provides the vendor with the date on which the consignment must be delivered to the warehouse. On the allotted date vendor vehicle(s) comes to the warehouse. The details of the purchase order placed can also be checked by the warehouse personnel in SAP.

Receiving - Vendors do not come in direct contact with the warehouses and hence time scheduling for vehicle arrival is not followed. Vehicles are unloaded on a first-in-first-out (FIFO) basis. Usually, 10-15 trucks per day come in from the vendors/customers for unloading. Firstly, documents are verified before any unloading takes places. If the vehicles are from vendors, the documents to be carried by the vendor representative (usually the driver) include the purchase order, LR copy and invoice. But if the vehicle is from one of the stores (return to vendors), then the documents to be produced are gate pass, invoice, STN (stock transfer note) and VAT form.

If the documents are in order the consignment is received into the warehouse. Depending on the size of the consignment the unloading time varies between one to two hours. The boxes are placed on to the pallet after unloaded from the vehicle. One of the security personnel keeps track of the number of boxes being unloading from the truck. Purchase orders are placed for individual store requirements, rather than being ordered in bulk and then segregating after being received at the warehouse. This eases the work for the warehouse personnel.

Once the goods are unloaded, Inbound Receipt Number (IRN) is generated in SAP confirming the receipt of the purchase order. This gives the details about the vendor name, purchase order received, LR no., date and time of receipt of the consignment. Goods are now moved near stationary computer terminal having wired barcode
scanner. Each article received is scanned against SAP interface. As SAP already has data regarding the articles to be received, scanning of each of article is just a verification and validation of the goods received against the purchase order. After all the articles are scanned Goods Receipt Note (GRN) is generated in the ERP software and waved. This note provides details regarding the goods actually received from the vendor and their quantities. This is formal acceptance of the goods into the warehouse. On an average 15000 SKUs are received each day. The complete process of document verification, IRN creation and GRN comprises the receiving activity.

**Dispatch** - Goods received are not stored in the warehouse for more than 24 hours. As the goods do not stay in the warehouse for a long time, racking and stacking becomes unnecessary. After GRN, the pallets containing the goods are moved to their respective store location. These locations are places in the warehouse where all the goods meant for a particular store are placed before they are loaded on to the vehicles and dispatched.

Goods cannot be dispatched to stores without the Stock Transfer Order (STO) which has to be given by the category team. Category team has access to the information regarding the goods waiting for dispatch and also the requirements and space availability at stores. Accordingly a stock transfer order is generated for transfer of goods to the store. An STO is done through SAP. Once the STO is received, warehouse orders the vehicle.

Dispatch or shipping is reverse of receiving. Here again, documents have to be produced. When the goods are being sent to the stores, the documents to be carried include a stock transfer note (STN), VAT form, gate pass and LR copy. STN gives the detailed description of goods being sent and their prices. Along with the above mentioned documents, an invoice is also required when goods are being returned to the vendors.

At the dock for dispatch, goods are loaded on to the vehicles. Security personnel keep tab on the number of boxes loaded on to the vehicle. Usually, a warehouse employee is also present to check whether correct goods are being loaded. Usually a copy of STN is used for this verification. The warehouse employee marks against the article as and when they are loaded on to the truck.
The loading activity also takes about one to two hours depending on the size of the consignment. Usually, the amount of goods received and amount of goods dispatched remain the same. These observations are used to chart the current state value stream map of the process.

**Warehouse Value Stream Map**

The current state value stream map show how the warehouse currently operates and serves as the foundation for the future changes. The map starts with the shipping area and works back through the warehouse process to the production area and to the suppliers. It is also useful to track a product family order through the warehouse operation. The production control information flow is shown to determine how the warehouse processes are being scheduled and controlled. At the bottom of the map, the total process time and lead time are calculated for a typical product family unit or order.

The current state value stream map serves as the starting point for developing the future state. The current state value stream map as shown in Figure 7.1 reveals a number of opportunities to reduce lead time and processing time in the warehouse, including the following:

- reduction in material handling time in order picking, putaway, and palletizing
- reliability issues with the strapping and metal detection machines
- reduction in truck loading time
- reduction in time spent checking inventory location and aging

Using the current state map, the goal in developing the future state map is to make the flow continuous and to eliminate as much waste as possible. Lead time is shortened as much as possible by implementing lean techniques. The flow in the future state map is built around the takt time, or how frequently a unit must be completed to meet customer demand. Takt time is simply the available working time per shift divided by the rate of customer demand per shift.
7.4.2 Evaluating the Current System

The current system is evaluated based on the value stream map as shown in Figure 7.4. The current process has a cycle time of 773 minutes of which 537 minutes is non value added time. A lot of time is wasted as the supplier has to wait about an hour before the unloading can take place. There is no system to schedule the arrival of vehicles. Since a flow through process is followed the goods are to be stored on the floor till they are dispatched. Amount of goods that can be stored directly corresponds to the total floor space available. The cubical space is not effectively utilized. Minimal racking is available to store return-to-vendor goods. But with the available infrastructure it is difficult to track and retrieve these items.

The current process has reached threshold capacity it can handle with the rising number of new stores being opened the process is impractical to follow. Also, with the company planning to consolidate all warehouses across south India the number of stores to which the warehouse serves, increases.
7.4.3 Proposed System

The future state value stream map is drawn incorporating WMS, Put-to-light system and racking stacking infrastructure. As shown in the map, the cycle time of the process reduces to 236 minutes. The non value added time reduces to 95 minutes. The manpower required is reduced by 40 percent. The process wise improvements are shown in the table 7.2.

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**Fig. 7.2: Proposed System Value Stream Map of the warehouse**
Table 7.2 Performance Improvements Warehouse after WMS Implementation

<table>
<thead>
<tr>
<th>Process</th>
<th>Time Savings per Order (in Minutes)</th>
<th>Process Improvement (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiving</td>
<td>159</td>
<td>68</td>
</tr>
<tr>
<td>Put-Away</td>
<td>14</td>
<td>36.84</td>
</tr>
<tr>
<td>Picking</td>
<td>49</td>
<td>77.78</td>
</tr>
<tr>
<td>Packaging</td>
<td>35</td>
<td>68.62</td>
</tr>
<tr>
<td>Dispatch</td>
<td>424</td>
<td>94.2</td>
</tr>
</tbody>
</table>

7.4.4 Performance Improvements

Apart from the tangible benefits listed above, there are many intangible benefits of implementing the WMS. Some the performance improving benefits are listed below:

- With WMS, time scheduling of vehicle is possible. This reduces the waiting of the supplier.
- With Advanced Shipment Note, the warehouse has prior information about the goods it is about to receive.
- WMS assisted put-away of goods is now possible.
- 100 percent goods traceability. With RF infrastructure in place the goods can be pin pointed to exact their location.
- Algorithm based picking simplifies picking operation.
- Auto updating of information prevents manual data entry and also reduces error rates.
- With many reports that can be generated, decision making is easier.
- Processing one order requires 19 sheets in a manual system while with WMS the paper consumption per order reduces to 4 sheets.

7.5 Cost Benefit Analysis

The cost- benefit analysis for implementation of WMS is done. This was done by estimating the Net Present Value of the savings. These tools can provide a good estimate of the economic justification for the system and help gain early support from company leadership.
Net Present Value (NPV): NPV calculates the net monetary gain or loss that is expected from a project by discounting all expected future cash flows to the present time, using the required corporate rate of return. In developing an NPV calculation, it is helpful to sketch the relevant cash flows over the given planning horizon. Generally, the initial cash outlay and project planning are recorded in time 0 with all future relevant cash flows in months or year.

Assumptions made for calculations of cost benefit analysis

The following are the assumptions made for calculating the cost benefit analysis of implementing the warehouse management system.

- Implementation period is assumed to be 6 months
- Capital is borrowed at an interest rate of 10% for a period of 2 years
- Transportation prices is assumed to increase by 10% once in the time horizon
- Cost Figures may have a deviation of 10-15 percent than that of actual Figures
- Losses incurred during implementation are Rs. 10,00,000

7.5.1 Initial Investment Breakup of the Warehouse management system

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software Licensing Fee</td>
<td>30,00,000</td>
</tr>
<tr>
<td></td>
<td>(Rs. 1,50,000 per user/3 years* 20 users)</td>
</tr>
<tr>
<td>Radio Frequency Infrastructure:</td>
<td>20,00,000</td>
</tr>
<tr>
<td>Server and Workstations:</td>
<td>20,00,000</td>
</tr>
<tr>
<td>Hand Held Terminals:</td>
<td>60,00,000</td>
</tr>
<tr>
<td></td>
<td>(Rs. 80,000/terminal+ Rs. 20,000 for AMC/terminal*60 users)</td>
</tr>
<tr>
<td>Racking:</td>
<td>1,00,00,000</td>
</tr>
<tr>
<td>Implementation Consultants:</td>
<td>20,00,000</td>
</tr>
<tr>
<td>Training costs:</td>
<td>10,00,000</td>
</tr>
<tr>
<td>Pallet Trucks:</td>
<td>40,00,000</td>
</tr>
<tr>
<td></td>
<td>(Rs. 13,00,000*3 Trucks)</td>
</tr>
<tr>
<td>Pick to Light System:</td>
<td>1,00,00,000</td>
</tr>
<tr>
<td><strong>Total Investment:</strong></td>
<td><strong>4,10,00,000</strong></td>
</tr>
</tbody>
</table>
Expenses
The Initial Investment bears equal distribution during the 6 month phase. The cash flow diagram below shows the expenses. As seen from the diagram a total of Rs 87,31,942 is spent equally for the six months and later it reduces to Rs 18,91,942 for the remaining span of time.

Fig. 7.3: CFD of Expenses in WMS implementation

Fig. 7.4 CFD of Savings after WMS implementation

Key Savings
The tangible savings due to implementation of WMS are:
- consolidation of warehouses
- manpower layoff
As a result of consolidation of warehouses the savings can be seen

- Average monthly operating cost/warehouse: Rs. 6,00,000
- Average Cost to Company/employee/month: Rs. 15,000
- Current warehousing and logistics cost of Rs. 4.01/SKU reducing to Rs. 2.23/SKU

The initial savings are due to shut down of warehouses.

The net cash flow diagram showing both expenses and savings is given below.

![Net Cash Flow Diagram](image)

**Fig.7.5 Net Cash Flow Diagram of a WMS implementation**

The analysis shows that the benefits exceed the investments. WMS implementation is a capital investment. It takes some time to break even. But strategically, it offers premium advantage to the company.

**Summary**

The implementation of WMS for a company demands significant investment and time period (several months) which has to be justified with the benefits obtained after implementation. The justification involves the excellent analysis of the current situation of the warehouse and warehouse operation for a specific period of time tuning the WMS. This chapter showed the justification of benefits for implementing WMS with the help of a case study.