

Impact of Warehouse Management System in a Supply Chain

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ABSTRACT

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. In today's competitive market environment companies are continuously forced to improve their warehousing operations. Many companies have also customized their value proposition to increase their customer service levels, which has led to changes in the role of warehouses. This paper highlights the findings of the study carried out to evaluate performance levels and enhance productivity of the manual warehouses by developing a WMS framework and cost benefit analysis.

General Terms

Supply chain, Warehouse Management system.

Keywords

Warehouse management system, supply chain, cost benefit analysis, value stream mapping.

1. INTRODUCTION

A warehouse is a facility in the supply chain to consolidate products to reduce transportation cost, achieve economies of scale in manufacturing or in purchasing [1] or provide value-added processes and shorten response time [2]. Warehousing has also been recognized as one of the main operations where companies can provide tailored services for their customers and gain competitive advantage. There are various types of warehouses: they can be classified into production warehouses and distribution centers [3] and by their roles in the supply chain they can be classified as raw materials warehouses, work-in-process warehouses, finished good warehouses, distribution warehouses, fulfillment warehouses, local warehouses direct to customer demand, and value-added service warehouses [4].

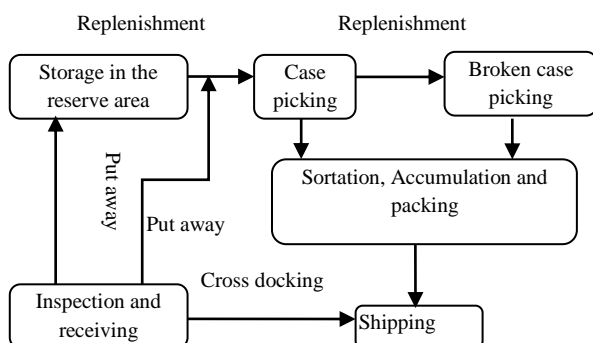


Fig 1. Typical warehouse functions

As mentioned above the heterogeneous warehouses have different operations. However, most of them share some general pattern of material flow, and typical warehouse operations include: receiving, putaway, internal replenishment, order picking, accumulating and sorting, packing, cross docking, and shipping (Figure- 1) [5]

Warehouses have been going through various challenges such as – supply chains are becoming more integrated and shorter, globalized operation, customers are more demanding and technology changes are occurring rapidly. In order to cope up with these challenges organizations are adopting innovative approaches such as warehouse management system.

A warehouse management system or WMS primarily aims to control the movement and storage of materials within a warehouse and process the associated transactions, including shipping, receiving, put-away and picking. 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 utilize 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 primary function of a warehouse control system is to receive information from the upper level host system, most often being the warehouse management system, and translate it for the daily operations. A common goal is to ensure a situation where warehouse employees never have to retype information because it already lies in one system or is collected automatically. Warehouse control system is usually the interface that is used to manage processes, people and equipment on the operational level.

Based on warehouse control system, literature distinguishes three types of warehouse management systems [6]:

- **Basic WMS** – This system is apt to support stock and location control only. It is mainly used to register information. Storing and picking instructions may be generated by the system and possibly displayed on RF-terminals. The warehouse management information is simple and focuses on throughput mainly.

- **Advanced WMS** – Above the functionality offered by a basic WMS, an advanced WMS is able to plan resources and activities to synchronize the flow of goods in the warehouse. The WMS focuses on throughput, stock and capacity analysis.
- **Complex WMS** – With a complex WMS the warehouse or group of warehouses can be optimized. Information is available about each product in terms of where it is located (tracking and tracing), what is its destination and why (planning, execution and control). Further, a complex system offers additional functionality like transportation, dock door, and value added logistics planning which help to optimize the warehouse operations as a whole.

Warehouse management systems can be stand alone systems or modules of an ERP (Enterprise Resource Planning) system or supply chain execution suite. The primary purpose of a WMS is to control the movement and storage of materials within a warehouse. The WMS can be deployed as a paper-based, RF/wireless based or combination of both.

2. LITERATURE REVIEW

Warehousing takes up to between 2% and 5% of the cost of sales of a corporation [7] and with today's highly competitive global business environment organizations are emphasizing on Return on Assets, and hence minimizing warehousing costs has become an important business issue. Many firms are automating their basic warehousing functions to achieve the increase in throughput rates or inventory turns required for their warehousing operations to be cost effective.

It is necessary to allocate warehouse resources efficiently and effectively to enhance the productivity and reduce the operation costs of the warehouse [8]. One vital area determining the efficiency of warehouse is the determination of the proper storage locations for potentially thousands of products in a warehouse. Various factors affecting the storage assignment like order picking method, size and layout of the storage system, material handling system, product characteristics, demand trends, turnover rates and space requirements are being extensively studied. It has been suggested that selecting appropriate storage assignment policies (i.e. random, dedicated or class-based) and routing methods (i.e. transversal, return or combined) with regards to above factors is a possible solution to improve the efficiency [9]. Various decision support models and solution algorithms have also been established to solve warehouse operation planning problems [10].

The use of information systems for warehouse management is studied extensively in literature. Complexity of warehouse management is indicated among others by amount and heterogeneity of handled products, the extent of overlap between them, amount and type of technology as well as characteristics of associated processes. As the complexity increases it becomes necessary to use Warehouse management systems for handling warehouse resources and to monitor warehouse operations. The warehouses with a high amount of processed order lines and amount of stock keeping units will be best supported by customized software. 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 [6].

RFID technology is adopted to facilitate the collection and sharing of data in a warehouse. Tests are performed for evaluating the reading performance of both the active and passive RFID apparatus. Implementing RFID technologies requires a thorough cost and benefit analysis of implementation. The costs of RFID implementation include tag reader costs, communication costs and other infrastructure costs. RFID can improve the automatic checkout process at a retail store, so it can reduce inventory costs as a result of more efficient shelf replenishment. RFID technologies can support the redesign of business processes; improve data quality; real-time data collection; synchronization and information sharing between the players of supply chain [10]. RFID implementation can also bring about additional benefits such as reduction losses due to shop lifting and increased use of point of sale applications [11].

Implementation of Warehouse Management System (WMS) will necessarily provide an increase in accuracy, reduction in labor costs if the labor employed to maintain the system is less than the labor saved on the warehouse floor and a greater ability to service the customer by reducing cycle times. WMS will not only lead in inventory reduction but also in greater storage capacity. An increase in accuracy and efficiency of the receiving process might lead to reduction in level of safety stock required. But the consequence of this reduction will hardly be visible to the overall inventory levels. WMS might just not affect the factors (lot sizing, lead times and demand variability) controlling the inventory levels. However WMS is instrumental in more efficient and organized that leads to increased storage capacity [8].

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. The firm should be prepared to change the entire process and system storage. Only WMS implementations without changing processes show that does not lead to cost savings or efficiency improvements, it will only reduce errors due to human factors.

3. WAREHOUSE PERFORMANCE MEASUREMENT

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.

The metrics for measuring performance in a warehouse fall into three main categories which includes order fulfillment, inventory management and warehouse productivity.

The establishment of metrics for auditing warehouse performance and assessment of WMS potential as a basis for investment justification should be the first steps in any WMS project [13]. The identification of proper metrics and opportunities for improvement can be a preliminary justification to determine potential payback [14]. The following metrics supplements the above process.

Table 1 – Performance Metrics of a warehouse

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

4. CASE STUDY

The study was conducted at India’s biggest retail company, which has developed expertise in Supply Chain Management of consumer product categories such as Fashion, Food and General Merchandise. 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 per year. This requires 30 distinct supply chains to be managed simultaneously, each with their own specific requirements that require customized solutions.

Out of the three warehouses where the study was taken up, one had automated WMS and the other two warehouses were manually run and had a high cycle time of 773 minutes. The retail chain company possessed three more warehouses which were catering to a total of 14 stores across south India. With the company planning to add more stores and establish a

centralized warehouse this chain would become inefficient. In order to improve the efficiency a study was taken to analyse the impact of implementation of WMS in these warehouses.

The study began with the understanding the current state of operations of the warehouses. Value stream maps were used for the same. Value Stream Mapping is the simple process of directly observing the flow of information and material as they occur and summarizing them visually. A Value Stream involves all of the steps, both value added and non-value added, required to bring a product or service through the process steps. It is a visual tool used to help see the hidden waste and sources of waste. A Current State Map is drawn to document how things actually operate (this is the “as-is” process). Then, a Future System Map (how it should be) is developed to design a lean process flow through the elimination of the root causes of waste and through process improvements all leading to an implementation The current value stream map used in the study is as shown in figure 2.

In these warehouses, the goods were received in bulk and put-away in racks. On the receipt of order, articles were picked, packed and dispatched. The process was tedious to carry out as no WMS was available. Though scanners were used for Goods Receipt Note in these warehouses, it was still considered a manual warehouse. Many vendors providing goods for the warehouse were still sending the goods directly to the stores then to the warehouse owing to the infrastructure and capacity constraints. This greatly increases the logistics cost involved.

The current process had a cycle time of 773 minutes of which 537 minutes was non-value added time. A lot of time was wasted as the supplier had to wait about an hour before the unloading can take place. There was no system to schedule time for the arrival of vehicles. Since a flow through process was followed the goods were to be stored on the floor till they were dispatched. Amount of goods that can be stored directly corresponds to the total floor space available. The cubical space was not effectively utilized. Minimal racking was available to store “return to vendor goods”. With limited available infrastructure it was difficult to track and retrieve these items.

The future state value stream map is drawn incorporating WMS, Put –to –light system and racking stacking infrastructure and is shown in figure 3. 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 2

Table 2. Performance Improvements at Warehouse after WMS Implementation

Process	Time Savings per Order (in mins)	Process Improvement (%)
Receiving	159	68
Put-Away	14	36.84
Picking	49	77.78
Packaging	35	68.62
Dispatch	424	94.2

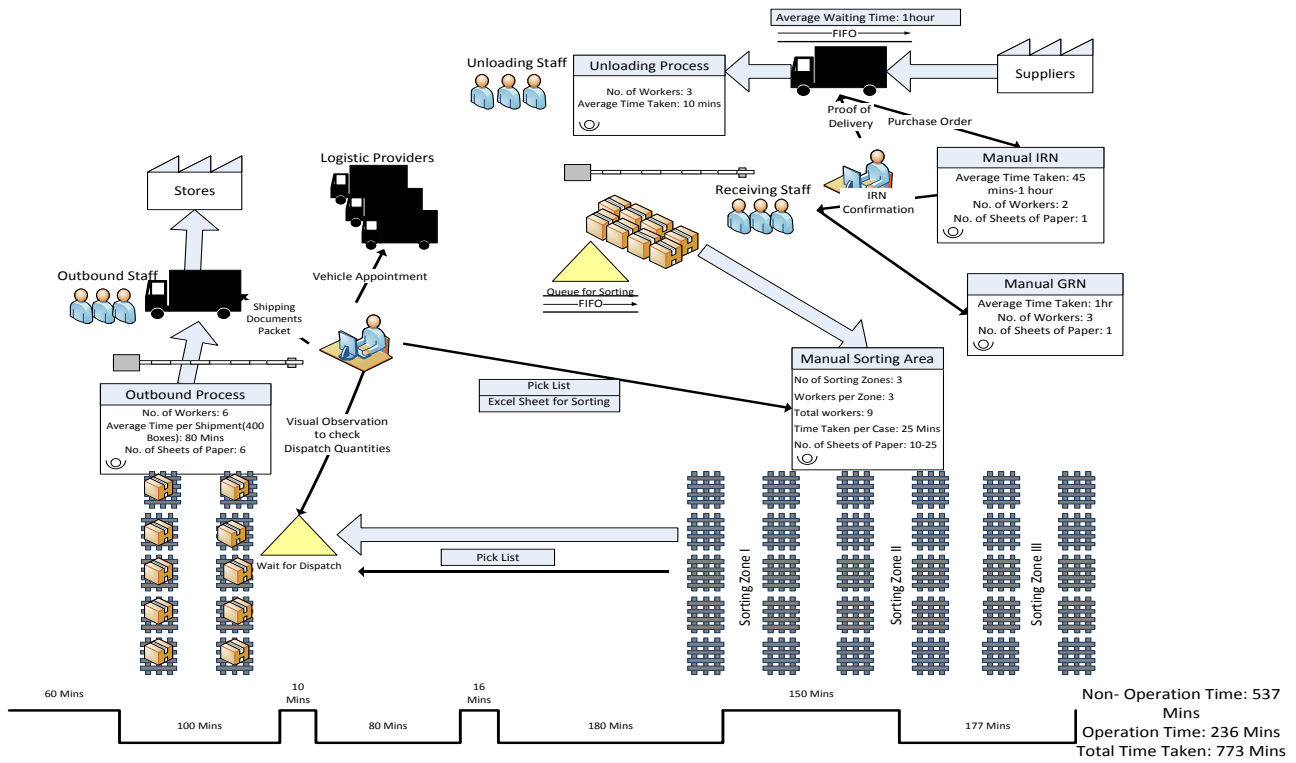


Fig 2: Current state of the warehouse

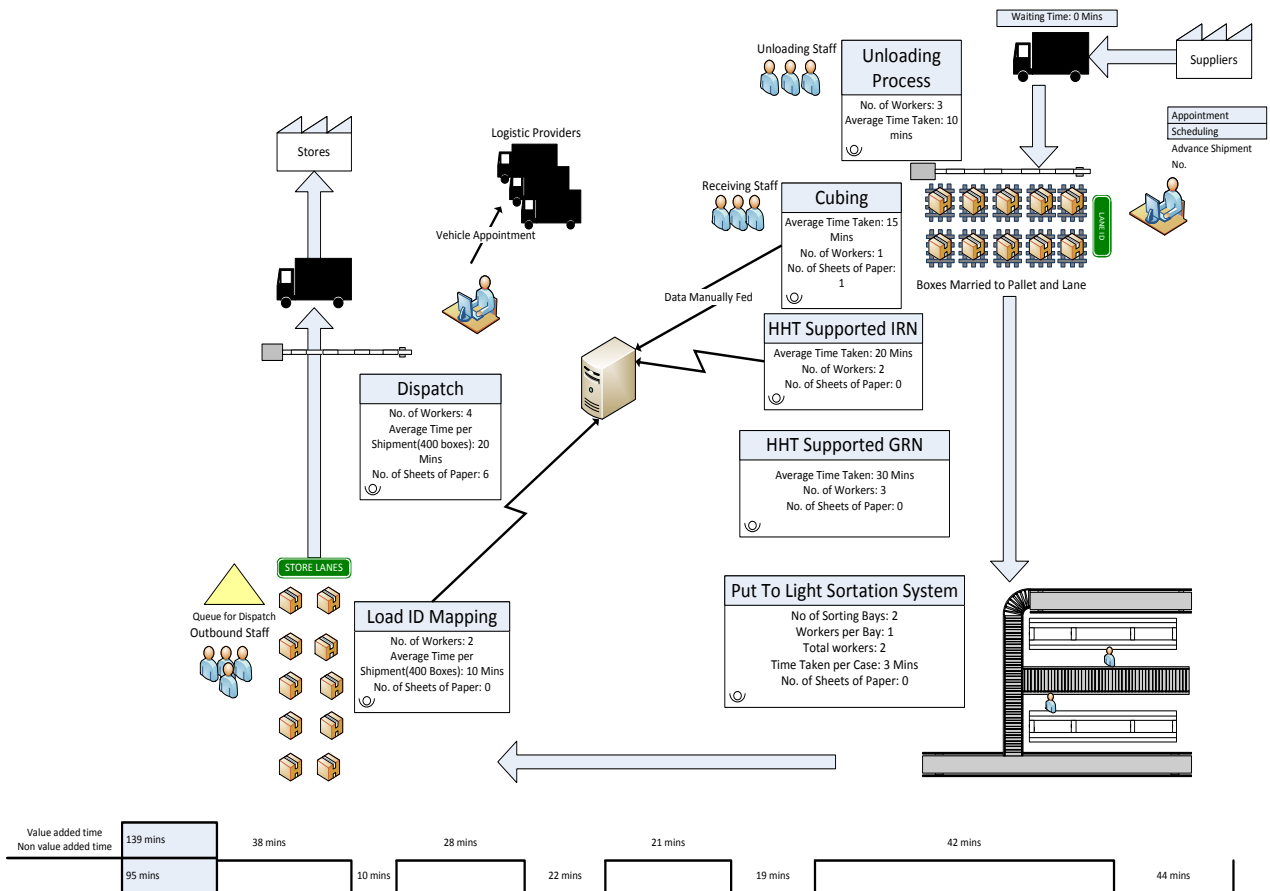


Fig 3: Future state of the warehouse

4.1 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 enabling 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 assisted.
- Processing one order requires 19 sheets in a manual system while with WMS the paper consumption per order reduces to 4 sheets.

The table 3 shows a comparison of WMS to Non WMS warehouse in terms of performance metrics adoption.

Table 3 Comparison of WMS / Non-WMS

PERFORMANCE METRICS		
	Non WMS	WMS
1. Receiving		
Appointment Scheduling	No	Yes
Dock Scheduling	No	Yes
Is it ASN enabled scheduling?	No	Yes
2. Put-away		
Space Allocation	Random	Algorithm Based
If Batch wise allocation, FEFO concept possible	No	Yes
3. Picking		
Pick Accuracy	Low	High
Picking Sequence	Random	Algorithm Based
Whether opportunity to cluster pick	No	Yes
4. Overall Time	773	236
5. Traceability	Poor	100 % Tracking
6. Capacity	6000/day	24000/day
7. Manpower	97	57

4.2 Cost Benefit Analysis

The cost- benefit analysis for implementation of WMS in one of the warehouse is done. This was done by estimating the Net Present Value of the savings. The initial investment breakup for implementing WMS is as shown in table 4

Assumptions:

- 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

Table 4: Initial Investment Breakup

Software Licensing Fee	Rs. 30,00,000 (Rs. 1,50,000 per user/ 3 years * 20 users)
Radio Frequency Infrastructure:	Rs. 20,00,000
Server and Workstations:	Rs. 20,00,000
Hand Held Terminals:	Rs. 60,00,000 (Rs. 80,000/terminal+ Rs. 20,000 for AMC/ terminal * 60 users)
Racking:	Rs. 1,00,00,000
Consultants:	Rs. 20,00,000
Training costs:	Rs. 10,00,000
Pallet Trucks:	Rs. 40,00,000 (Rs. 13,00,000* 3 Trucks)
Pick to Light System:	Rs. 1,00,00,000
Total Investment:	Rs. 4,10,00,000

Expenses

The Initial Investment bears equal distribution during the 6 month phase. The cash flow diagram below shows the expenses.

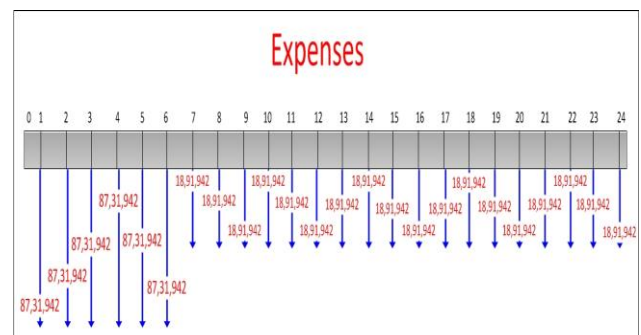


Fig 4. Cash flow diagram of the expenses

Key Savings

The tangible savings due to implementation of WMS are:

- consolidation of warehouses
- manpower layoff

The initial savings are due to shut down of warehouses. Currently there are four Factory warehouses one each in Hyderabad, Vijayawada, Vishakhapatnam and Bangalore. A central warehouse in Bangalore can be used to cater to all stores in South India when WMS is implemented. With a central warehouse in place there is no requirement for the other three warehouses which can be closed down. Once the consolidation of all the warehouses is complete the manpower is gradually reduced.

The manpower reduction is assumed to be about 40 percent. The layoff is done over a period of four months. Once this process is complete the savings reach its peak. Now there is slight increase in transportation cost as goods have to be sent from Bangalore to other states as well. Thus there is a small dip in savings from the 18th month. This conservative estimate shows that the payback period is about 36 months and net savings of Rs. 19,60,000.

The analysis shows 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.

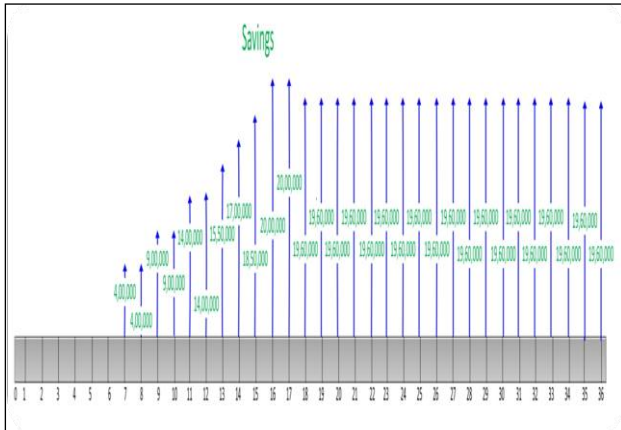


Fig 5. Cumulative Flow Diagram of Savings after WMS implementation

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

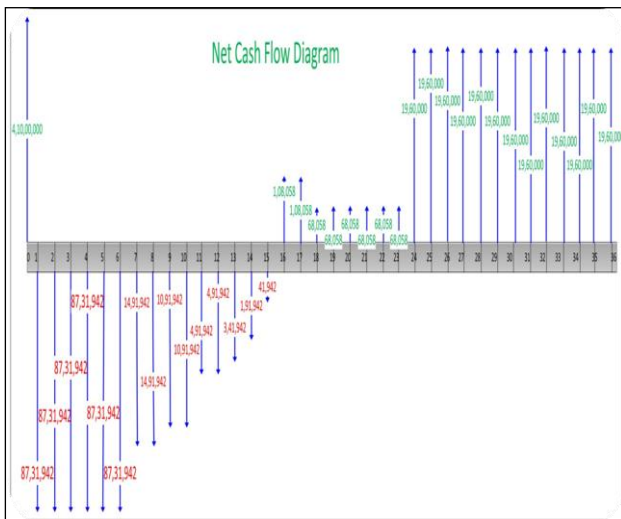


Fig 6. Net Cash Flow Diagram of a WMS implementation

5. CONCLUSION

As an impact of large product varieties and shortened customer response times there is a greater emphasis on the ability of the organizations to establish smooth and efficient logistics operations. In this regard, warehouses play a vital role because they function as nodes that direct the flow of materials within a distribution network. The effects of organizing warehousing activities can directly be seen in

customer service levels, lead times, and the cost structure of a company. Hence we can conclude that warehousing influences the performance of an entire supply chain.

With the boom in organized retailing it becomes necessary for the players to continuously improve their process. The retailers have to strive continuously to reduce their costs. Technology being an enabler improved technology has to be incorporated into the current processes. Also the processes have to be designed in such a way that they provide for incorporating changes.

The value stream mappings of the current systems showed many bottlenecks that prevail in the system. These bottlenecks restricted the capacity the warehouses could handle. Performance and productivity of the warehouse suffered as the operations were manually carried when it could be more easily and more effectively done using machines. With WMS implementation the cycle time of the process also decreases. The cycle time reduces from 773 minutes to 236 minutes. The cost benefit analysis for WMS implementation in warehouse shows a savings of Rs. 19,60,000 per month. The study proves WMS to be an enabling factor for performance and productivity improvement. The productivity of a WMS warehouse is way higher than when the operations are manually performed.

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7. REFERENCES

- [1] Bartholdi III JJ, Hackman ST (2006), Warehouse and distribution science. www.warehouse-science.com
- [2] Gong Y, De Koster MBM (2008), A polling-based dynamic order picking system for online retailers. *IIE Transactions* 40 pages:1070–1082
- [3] Ghiani G, Laporte G, Musmanno R (2004), *Introduction to Logistics Systems Planning and Control*. John Wiley & Sons, England
- [4] Frazelle E (2001), *World-class warehousing and material handling*. McGraw-Hill, New York
- [5] Tompkins JA, White JA, Bozer YA, Frazelle EH, Tanchoco JMA (2003), *Facilities planning*. John Wiley & Sons, NJ
- [6] Faber, Nynke; De Koster, Rene B. M. (2002), Linking warehouse complexity to warehouse planning and control structure: An exploratory study of the use of warehouse management information systems. *International Journal of Physical Distribution & Logistics Management* [online]. vol. 32,(5), pages. 381 – 395
- [7] Heung Suk Hwang, Gyu Sung Cho (2006), A performance evaluation model for order picking warehouse design, *Computers & Industrial Engineering* Vol. 51(2), pages: 335-342.
- [8] T.C. Poon, K.L. Choy, Harry K.H. Chow, Henry C.W. Lau, Felix T.S. Chan, K.C. Ho (2009), A RFID case-based logistics resource management system for managing order-picking operations in warehouses, *Expert Systems with Applications*, Vol. 36(4), pages 8277-8301

- [9] Felix T.S. Chan, H.K. Chan (2011), Improving the productivity of order picking of a manual-pick and multi-level rack distribution warehouse through the implementation of class-based storage, *Expert Systems with Applications*, Vol. 38(3), pages 2686–2700.
- [10] Jinxiang Gu, Marc Goetschalckx, Leon F. McGinnis (2007), Research on warehouse operation: A comprehensive review, *European Journal of Operational Research*, Vol. 177(1), pages 1–21.
- [11] S.F. Wamba, T.R. Coltman, and K. Michael (2008). RFID-Enabled warehouse optimisation: Lessons from early adopters in the 3PL industry. ICIS Ancillary meeting, Paris, France, pages 1-12.
- [12] J. Sounderpandian, R. V. Boppana, S. Chalasani, and A. M. Madni. (2007) Models for cost-benefit analysis of RFID implementations in retail stores. *IEEE Systems Journal*, Vol(1), pp105-114,.
- [13] Chris Caplice and Yossi Sheffi (1995), A review and evaluation of logistics performance measurement systems, *The International journal of Logistics Management*, Vol. 6(1), pages 61-74.
- [14] John M Hill (2002), Justifying warehouse management systems, white paper, ESYNC.