EVALUATING A COMPUTERIZED WAREHOUSE MANAGEMENT SYSTEM

Z. Ali and K. A. BuBshait
Research Institute, King Fahd University of Petroleum
and Minerals, Dhahran, Saudi Arabia

ABSTRACT. A commonly faced problem for the warehouse management is to select an appropriate computerized system for their warehouse operations among the large variety available on the market. The management need to decide if the required software should be developed in-house or purchased from those commercially available. It is often observed that the acquired systems often do not work satisfactorily and as a consequence undergo periodic modifications and evaluations. In order to minimize these, a study need to be conducted to select the most appropriate software. In this paper, we present the major functions of the warehouse management system to facilitate in developing such systems and an instrument is provided to select a suitable software from those commercially available.

1. INTRODUCTION
Maintenance operations of a manufacturing organization depend upon different factors including warehouse management. Warehouse personnel must have computer support to help them plan their operations, control operating costs more efficiently, and effectively implement policies pertaining to their warehouse operations. A commonly faced problem is how to select an appropriate warehouse management system for intended use from those available. A large variety of computer software is available on the market. Organizations often spend significant resources and time to search for an appropriate warehouse management software including the use of consultants. It is observed that the acquired systems often do not work satisfactorily because the software designers/programmers often do not have sufficient experience of maintenance and warehouse management related operations [1]. As a consequence, such software systems periodically undergo modifications and require a periodic evaluation. Furthermore, the management need to decide if the required software to be developed in-house or purchased from those commercially available. Evaluating information system is an integral part of the development life cycle and has been a long neglected problem [2]. Often, the warehouse management systems are developed as a part of the computerized maintenance management systems. A framework to evaluate a computerized maintenance management system has been suggested in the literature [3]. This paper describes the major functions of a computerized warehouse management system to facilitate in developing an efficient system or the post-implementation evaluation (PIE), and suggests an instrument to select a suitable software from those commercially available for a specific use.

2. EVALUATION PROBLEM
Literature survey has shown that no generally accepted evaluation measures/procedures for information systems prevail. Different authors have suggested different measures for the success of an information system. A notable disagreement for each of these measures exist in the literature. Sander [4] has reported the results of a survey of post-implementation evaluation measures of an information system. Conrath [2] has suggested the use of a combination of measures to make up for individual measure limitations.

The measures include: (1) user satisfaction; (2) system effectiveness; (3) value of benefits vs costs; and (4) system utilization. The system effectiveness can be regarded as a single
pragmatic measure [4, 5, 6]. More specifically, a general framework to evaluate the 
warehouse management system for maintenance operation is not available. The framework for 
such an evaluation suggested in this article is based upon the concept of system effectiveness. The 
effectiveness measure is based upon the understanding of requirements or needs. It 
should be noted that the requirements of a warehouse organization from its management 
system are dynamic rather than static. The use of information systems, more specifically, 
warehouse management systems is common in today's industries because of their contribution 
in the organizational productivity. Organizations are looking for and adopting new state of the 
art methods to improve their productivity and efficiency. As a result, the requirements from 
these computerized systems become dynamic. Because of this, the computerized warehouse 
management systems are replaced by more effective ones or evaluated periodically to identify 
and fill gaps between the system capabilities and demands from it.

In order to design an effective warehouse management system, or select an appropriate one 
from those available on the market, it is imperative to understand the warehouse functions and 
their purpose in warehouse organization.

3. FUNCTIONS OF WAREHOUSE MANAGEMENT

Functional requirements refer to what a computerized warehouse management system is 
supposed to do. It need be stated in sufficient details so that the system developer can prepare 
a functional design accordingly or use it to select a commercially available system. A recent 
survey [7] has shown that the pressure to computerize the warehouse is great and is a key to 
improving response times, but the level of understanding of needs, benefits and specific 
requirements is low. Warehouse management should pursue computerization after the 
objectives and expectations are defined and understood because warehouse management is the 
implementation of advanced techniques, methods, and technology to optimize all of its 
functions throughout the warehouse.

3.1 Top Management Commitment

Top management commitment and support is an essential requirement to have an effective 
inventory control. The upper management's dedication and commitment has been realized a 
unique and most powerful reason for improved inventory control [8].

3.2 Inventory Policies

The inventory policies refer to the review and ordering discipline used in controlling the 
inventory. Different techniques and state of the art methods are available to develop these 
policies [9]. These includes: a specific item to stock or not, holding level, priority, etc. Warehouse management should develop and implement fundamental policies before embracing 
more complex systems. This is also important for the solution to inefficient material 
management and realizing the amount of cash tied up in inventory.

3.3 Warehouse Planning

In order to avoid the warehouse operations drifting into fire-fighting anarchy, a sound planning 
is imperative. This includes tactical planning, contingency planning and strategic planning. 
Tactical planning deals with the day-to-day warehouse problems. Warehouse contingency 
planning refers to planned actions to guard against a predictable change in requirements 
allowing unpredictable time. Whereas the warehouse strategic planning means arrangements to 
deal with predictable future change in requirements allowing predictable timing [10]. CWMS 
can provide significant support in tactical planning.

3.4 Warehouse System

The warehouse management need to develop warehouse system that establishes and 
implements the warehouse policies. This includes: the organizational structure, 
responsibilities, procedures, facilities, and resources.

3.5 Warehouse Control System

Control refers to monitoring and keeping under constant check the warehouse activities. 
Warehouse management need establish an effective control system. This can be done using
different tools which include: tracking performance indicators and periodic management reviews.

Key factors effecting the productivity of warehouse operations include: warehouse organization and management, receiving and inspection, kitting, facilities, bench stock levels, residual material, repairable equipment, scrap, repair tools and equipment, inventory management, purchasing system, stock catalogue and spare parts manual, lead times, manning level, stock holding levels, productivity management, warehouse & maintenance coordination, and information system.

4. COMPUTERED SYSTEM - BUY OR DEVELOP?
A first decision to be made by the management is to decide if the computerized warehouse management system (CWMS) should be developed in-house or bought from those commercially available ones. An organization may undertake to develop their own CWMS when the organization's requirements are unique, when the programming complexity is low, and the software developing duration is short. On the other side, if the organizational requirements are not unique, the programming complexity is high and the software developing duration is expected to be long, selection of an appropriate one from those available on the market is worth considering.

In certain cases of special operating conditions, in order to reduce the software building project life-cycle and to eliminate developmental problems, an organization may consider acquiring a commercially available one and matching it with their own requirements through program fixes and program upgrades.

5. BASIC FUNCTIONS OF THE SYSTEM
The expectations from a CWMS may vary from one organization to another depending upon its operations. CWMS enables full control of all warehouse activities by the use of different modules or subsystems it offer. Table 1 shows a list of major functions and features of a CWMS.

In addition to this, the systems are often required to meet organizational Electronic Data Interchange (EDI) needs. Furthermore, the software need to support policies & control of high value rarely used items which constitute a major part of inventory stock and where traditional methods & models are not applicable. The principle of EDI is required to have a structure according to some international standard. Some related standards are ISO 9735, EN 29735, UN/EDIFACT and ANSI X12.

6. SELECTION OF AN APPROPRIATE SOFTWARE
A large variety of software is available on the market ranging in size, speed, capabilities, price, and hardware requirements. The best software solution is the one that offers best value to its users. The selection of an appropriate computerized warehouse management system can be performed using the following framework for the evaluation of available systems. The suggested framework consists of eight sequential steps described in the following subsections.

6.1 Setting System Objectives
Setting the objectives of the required system is the most important as well as most difficult aspect of any software selection project. The objectives include the identification of all supports and operations to be met by an integrated system. It must be based upon organization's current as well as future requirements. The future requirements might include supports to different forthcoming programs, e.g., the adaptation of ISO 9000 or JIT systems. The objectives should include: -
- support full control of all maintenance stores activities,
- support full control of all shop floor activities,
- provide complete help to streamline the purchasing function as it relates to the maintenance and inventory,
- provide complete automation of the purchasing function, and
- prepare periodic reports and conduct audits.
Table 1. Major functions and features of a computerized warehouse management system.

<table>
<thead>
<tr>
<th>Functions</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. INVENTORY MANAGEMENT</td>
<td></td>
</tr>
<tr>
<td>1. PARTS DEFINITION</td>
<td>Part, Manufacturer Part Number, Part Quantity,</td>
</tr>
<tr>
<td></td>
<td>Codification, Multiple facility/storeroom support,</td>
</tr>
<tr>
<td></td>
<td>Part keyword, Stock/non-stock items, Units of Measure, User Defined Part Fields</td>
</tr>
<tr>
<td>2. STORE ROOM TRANSACTIONS</td>
<td>Issues, Returns, Receipts, Adjustments Part Transaction Summary, LIFO (Last In First Out),</td>
</tr>
<tr>
<td></td>
<td>FIFO (First In First Out), Repaired Parts Tracks</td>
</tr>
<tr>
<td>3. PARTS ANALYSIS</td>
<td>EOQ, ABC Analysis for Parts Usage, XYZ Analysis for Parts Value, Reorder Point Smoothing Capability, Demand Forecasting, User Definition of smoothing algorithm, Different algorithms for different warehouse locations, Analysis of Service Levels by part category, Possibility of Different Scenario on service levels to determine resultant inventory levels, Usage History</td>
</tr>
<tr>
<td>4. CYCLE COUNT</td>
<td>Cycle Count Worksheet, Cycle Count Entry, Cycle Count Processing</td>
</tr>
<tr>
<td>5. PARTS INQUIRY</td>
<td>Holding Cost, Average Cost, Lead Times, Priority, Bin Location, Parts Reservation, Stock Status, Where used, Maximum Level, Minimum Level, Shortage Cost, Demand over a window, Quantity Discount</td>
</tr>
<tr>
<td>6. WAREHOUSE ANALYSIS</td>
<td>Service Level by Parts, Inventory Value Details, Inventory Value Summary, No Action, Obsolete Stock Identification, Part Class Code, Storeroom Class Code, Over Max, Usage History, Stockout Frequency</td>
</tr>
<tr>
<td>7. WAREHOUSE REPORTS</td>
<td>Obsolete Parts Identification, Backorders, Potential Stockouts, Stockout Report, Part Catalog, Storeroom Catalog, Stock Reorder, Storeroom Audit</td>
</tr>
<tr>
<td>8. INTERFACES</td>
<td>Maintenance, Purchasing, Shop Floor</td>
</tr>
<tr>
<td>B. PURCHASING CONTROL</td>
<td></td>
</tr>
<tr>
<td>1. BIDS SOLICITING FROM VENDORS</td>
<td>Quote Request, Vendor Quote Update, Vendor Quote Evaluation</td>
</tr>
<tr>
<td>2. SUPPLIER HISTORY</td>
<td>Total Shipment Cost, No. of over Shipments, No. of under Shipments, No. of Back Orders, Late Shipments, Damaged Goods Shipment Nos, Vendor Rating</td>
</tr>
<tr>
<td>3. <strong>BLANKET ORDER PROCESSING</strong></td>
<td>Entry for a specific Vendor Release, For cataloged /non-cataloged items, Equipment Rentals, Services, Repairs</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4. <strong>REQUISITION PROCESSING</strong></td>
<td>Entry, Unpriced Requisition Update, Approval, Buyer Assignment and Update, Requisition Inquiry</td>
</tr>
<tr>
<td>5. <strong>PURCHASE ORDER PROCESSING</strong></td>
<td>Entry, Print, Place, Invoice Update, Invoice Data Extraction, Close, Archive</td>
</tr>
<tr>
<td>6. <strong>RECEIPTS</strong></td>
<td>Receipts, Inspection Backlog Inquiry, Inspections, Return to Vendors, Receipts’ Inquiry, Inspection Inquiry, Storeroom Receipts</td>
</tr>
<tr>
<td>7. <strong>PURCHASE ORDER REPORTS</strong></td>
<td>Receipts Reports, Aging Reports, Status Reports, Item History Reports, Commitment by Vendor Reports, Vendor Performance Report, Receipt Exception Report, Return to Vendor Report</td>
</tr>
<tr>
<td>8. <strong>PURCHASE ORDER INQUIRIES</strong></td>
<td>Inquiry for Expediting, Inquiry for Status, inquiry of Purchase Order History, History by Vendor Inquiry, Changed Inquiry, Archived Inquiry, Purchase Parts Inquiry</td>
</tr>
<tr>
<td>9. <strong>PURCHASING DESCRIPTION</strong></td>
<td>Address of Company, Authorizer, Buyer, Standard Clauses, Currency Codes, Vendor Information, Shipment Type, Requester Initials, Rejection Cause, Code of Purchase Type, Payment Terms, Different Charges, Freight Terms</td>
</tr>
<tr>
<td>C. <strong>VENDOR EVALUATION</strong></td>
<td>Installation Support, Documented Installation Program, Documentation for Installation, User and Training Manuals, On-Site Training, Planned enhancement and Support program, Data Input guidance, Supplying Source Code, Company-specific modification support</td>
</tr>
</tbody>
</table>
6.2 Identification of Functions and Features
Prepare an exhaustive list of functions required in view of the objectives set in the previous steps. Each organization will have a set of objectives that differ somewhat from other organization. Then identify the features for each of the function identified. The list of functions and features need to be reviewed to ensure that those important for the organization are included. Finally, a checklist based upon functions and features be prepared.

6.3 Assigning Weights to Functions and Features
Not all the functions and features identified in the previous step are of equal importance. An important step is to assign numerical weights to each function and feature.

Let i = 1, . . . , n be the specific functions identified and let j = 1, . . . , m be the features which the system need to offer for each function. m may vary among different functions. Let \( W_{ij} \) be the relative weights of the features. These weights may be used in any range. For example a numerical weight of 10 can be used as a maximum. Negative weights can also be employed for a feature if its presence in the system would detract from system performance. The weight assigned to each function may be the sum of the weights of the features that comprise the function. Let \( W_1, W_2, \ldots, W_n \) be the resulting weights of the functions.

6.4 Selection of Candidate Systems
The organization should attempt to identify most recently available systems. This can be done by the search of current literature, visiting exhibits, systems used in known organizations, and using professional journals & magazines. An initial screening of the listed software can be done using the objectives, the functions and features, and other constraints which include: hardware requirements, mainframe/PC based, cost, etc.

6.5 Examination of System Documentation
The weeding process should begin when a list of candidate software has been prepared and literature/documentation on those systems has been obtained and examined. The weeding process may be based upon:

- non-availability of documentation
- quality of documentation
- system operation on-line or batch mode
- system friendliness, etc.

The outcome of this step is the collection and review of the descriptive literature and documentation on each of the candidate system. Also, a level II screening of the systems based upon the literature/documentation review.

6.6 On-Site Evaluation
On-site evaluations are essential element of software evaluation. The objective of on-site evaluations are to know the actual behavior of the systems in operational settings. Existing user sites must be preferred over the vendor sites. The table of functions and features along with the checklist is an important instrument to be used during on-site evaluations. Also, the operational performance, problems, and the support level by the vendor need to be discussed with the current users. This step ends up with the collection of performance data from the source organization.

6.7 Calculation of Performance Scores
Based upon the information obtained in the previous steps and the literature/documentation collected, this step aims at a comprehensive evaluation of the system on the final system list using the checklist tables of functions and features. At this time, each feature and function from the table must be taken one by one and compared with the capabilities or support provided by the software on the list. A numerical score \( S_{ij} \) must be assigned to each candidate software over a certain pre-decided scale (e.g., 10). Starting with the features of a function, the total weighted score of the ith function would be

524
\[ f_i = W_i \sum_{j=1}^{m} V_{ij} S_{ij}, \text{ for } i = 1, \ldots, n, \text{ and } W_i = \sum_{k=1}^{m} V_{ik}. \]  

(1)

Then a software score (SS) is given by

\[ SS = \sum_{i=1}^{n} \left( W_i \sum_{j=1}^{m} V_{ij} S_{ij} \right). \]

(2)

The SS can then be calculated for all the software under consideration and the candidate systems may be ranked according to their SS. It should be noted that though the number of candidate software can be in any number at this stage of evaluation but they will not exceed two or three if the previous steps are carried out effectively. Let \( SS_k, k = 1, \ldots, L \) be the composite software scores for the candidate systems. Then the software \( SS_{\text{max}} = \max (SS_1, \ldots, SS_L) \) can be preferred over the others. A general table of functions and features given in Table 1 can be used for this step.

6.8 Post-Installation Evaluation

After the software has been acquired, installed, and in operation for some period of time, the organization should evaluate this system. Before, this evaluation is performed the list of functions and features must be fine tuned in view of the experience gained. As a matter of fact the acquisition of a commercially available software is a matter of best fit. The software score (SS) should be calculated a new. If the new SS is significantly better than the one calculated before, this might indicate that a better choice was made or the warehouse organization's attitude towards the system has become more tolerant. In case the new SS is lower then the original SS, gaps must be identified and a corrective actions must be taken accordingly. This post-installation evaluation must be preferred during the warranty period.

ACKNOWLEDGMENT
The authors wish to acknowledge the support of the Research Institute of the King Fahd University of Petroleum and Minerals.

REFERENCES