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Guidelines to Select a Computerized Maintenance Management System

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GUIDELINES TO SELECT A COMPUTERIZED MAINTENANCE MANAGEMENT SYSTEM

by

Dattaraj Kamalapurkar

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Science in Engineering (Industrial)
Department of Industrial and Manufacturing Engineering

Western Michigan University
Kalamazoo, Michigan
December 2005
ACKNOWLEDGMENTS

This thesis could not have been completed without the support, guidance and encouragement from several people.

To begin with, I would like to express my deepest gratitude to my thesis committee chair, Dr. Azim Houshyar, for his support, guidance, encouragement and many constructive suggestions. His time and experience were an invaluable resource throughout the duration of this research. I would also like to thank my thesis committee members Dr. Bob White and Dr. Leonard Lamberson for their support, guidance and invaluable suggestions. Their experience and knowledge greatly helped in developing this thesis.

Next, I would like to thank the staff and faculty in the department of Industrial and Manufacturing Engineering for providing me with a friendly working environment. I would like to specially thank Dr. Paul Engelmann and Klazina Welch for all their help and support.

Finally, I would like to thank my family, specially my brother, Arun and my wonderful wife, Seema. She has been a source of encouragement and has been very supportive and understanding throughout this process.

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GUIDELINES TO SELECT A COMPUTERIZED MAINTENANCE MANAGEMENT SYSTEM

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Western Michigan University, 2005

In today's highly competitive global economy, maintenance personnel are presented with more difficult challenges than at any previous point in time. In order to meet these challenges, many maintenance managers tend to rely on Computerized Maintenance Management System (CMMS). When properly selected and implemented, CMMS is one of the most powerful cost reduction tools in any organization. However in reality, many CMMS implementations fail rather than achieve success. While there are many contributing factors, one major factor that greatly impacts successful implementation is selecting the right CMMS system. With more than 200 CMMS systems to choose from, selecting the right CMMS system is not a simple or easy task.

This research provides guidelines for CMMS selection and creates a CMMS Selection Tool, known as SELECTCMMS in Visual Basic software. SELECTCMMS provides various features and functions currently available in many CMMS systems. Using SELECTCMMS, manufacturing organizations can select all the features and functions needed in a CMMS system, specific to the needs of their organization. A detailed specifications document in Microsoft Word is automatically created, based on the features and functions selected. This document can be utilized to solicit proposals from different vendors to evaluate, select and implement the right CMMS system.
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INTRODUCTION

Brief Overview

During earlier times, maintenance was usually considered a necessary cost center that performed equipment maintenance and repairs to ensure continuous operation. However, in recent years, advances in new technologies and innovative maintenance practices have ensured that maintenance can play an important role in the overall profitability for many organizations. To enhance reliability of equipments, improve maintenance productivity and reduce maintenance expenses, many maintenance departments rely on Computerized Maintenance Management Systems (CMMS).

CMMS have proven in many industries to enhance maintenance productivity, reduce maintenance expenses and increase overall revenues by improving reliability of equipments (Call, 2003; Carroll and Wilmot, 2003). For example, CMMS can help to reduce inventory budget by maintaining an optimum level of spare parts, (based on history and future equipment usage) to prevent limited funds from being allocated for excess inventory. In addition, CMMS can help to setup and manage effective preventive, predictive and proactive maintenance programs, which will significantly improve equipment reliability, availability and utilization. Higher equipment availability and utilization enables production to enhance their productivity, which helps to generate higher profits for the company.

A CMMS is designed to manage maintenance transactions, the same way an Accounting Information Management System (AIMS) manages financial transactions. In the case of maintenance, the transactions are work orders instead of invoices. A typical CMMS helps maintenance organizations manage Equipments, Personnel, Work Orders, Inventory and Purchasing. The CMMS system receives input as a maintenance work
request from the “Work Request Module”. Using the information provided in the work request, the “Work Order Module” creates work orders (by assigning personnel, components, start time, end time, etc.), and tracks work in process. The “Equipment Module”, maintains and tracks all equipment details (and other assets) that need to be maintained. The “Inventory Module” ensures that spares are always maintained at a level both sufficient and cost-effective. It automatically generates purchase requisitions (or purchase orders) whenever quantities drop below a predetermined reorder point. In addition, inventory module ensures sufficient parts and materials are available for all scheduled work orders (both preventive and corrective work orders). The “Purchasing Module” generates purchase orders for stocked and non-stocked items, special orders, and services. It tracks open purchase orders, and ensures that all ordered parts are received on schedule and available for maintenance. The “Personnel Module” maintains and tracks personnel details, which helps in assigning the right personnel to the work orders. The “Preventive Maintenance Module” creates task schedule and assigns detail preventive maintenance tasks for any equipments or assets that need preventive maintenance. A task schedule specifies when and/or how often a particular preventive maintenance task should be performed. Using the “Reporting Module” the system generates many different reports, like labor cost, materials cost, equipment downtime, equipment availability, etc. Many advanced systems provide detail cost breakdowns for personnel time, materials used, work order details, purchasing details, maintenance tasks, repair history and many other details.

CMMS systems were initially used for hospital equipment maintenance, where critical breakdowns could lead to life threatening situations (Weir, 2004). In recent years, many companies in various industries have come to recognize the value of these systems as a means to enhance equipment reliability, improve maintenance productivity and generate higher profits.
Problem Background

Over the past decade, Computerized Maintenance Management Systems (CMMS) have evolved making them very attractive for implementation. However, selecting the right system has become much more difficult. With many vendors proclaiming the use of new technologies and other innovative approaches, it makes it more challenging to separate hype from reality. In general, some systems may seem right, but they may not be the best fit for a specific company. Some systems may look good, but may not offer the right features and functions needed for cost effective maintenance. While others may be too complicated to use or may not provide enough flexibility for the future.

When properly selected and implemented, CMMS is one of the most powerful cost reduction tools in any organization. However, in reality, many CMMS implementations fail, rather than achieve success. It has been estimated that nearly 70% of all CMMS efforts fail, many within the first year before the system even sees usage. While there are many contributing factors (like ineffective maintenance procedures, lack of adequate training) several implementation failures can be traced back to ineffective selection process (Vujicic, 2005; Weir, 2004; Mikes and Davis, 2001; Singer, 2000).

Selecting the right CMMS system can greatly influence the overall success of the CMMS implementation. However, selecting and implementing a CMMS is not a simple or an easy task. There are several challenges, which can very easily result in a failed implementation. During the CMMS selection process, many prospective users may have been consulted about what they would like from the system, but quite often, they are not in a position to comment, as they are not fully aware of what exactly they want and what features and functions are available in a CMMS system.

There is also a belief that many major brands of CMMS are basically very similar and that an organization should be able to select the best one, based on their budget.
That is clearly not the case, as there are significant differences between many different brands of CMMS systems. Unfortunately, the results of an ineffective selection process are usually not manifested until well into implementation. Quite often, it is not until after the installation is complete, that many users realize their new system does not meet their requirements and at this stage, it is already too late to make any changes. In addition, once a CMMS is implemented, a huge investment has already been committed. With the implementation of the wrong CMMS system, maintenance will not be in a position to show the return on investments (ROI), which can greatly damage the reputation of the maintenance personnel, and in some cases, can eventually lead to the failure of the company.

Aims and Objectives

The computerized maintenance management system (CMMS) is one of the most important and powerful tools in the arsenal of maintenance managers. Even though there is a lot of focus on selecting CMMS systems from a number of perspectives, the success rate for many of the purchased systems is still extremely low. A fully functioning CMMS is one of the most complex systems available. When we consider the fact, that there are more than 200 systems to choose from, then selecting the right CMMS can be a daunting task. With the proliferation of software options and their implications for other areas of the organization, maintenance managers face a greater challenge and risk in selecting the right CMMS for their organization.

The final selection should be based on the right features and functions available in a CMMS system, which compliment the maintenance practices and procedures of the organization. It should not be based on the vendors hyped up product presentation or on what fits with the computer network infrastructure or on the lowest bid. If CMMS is selected by the Information Technology department based solely on compatibility of the
software to the existing network or other enterprise applications, it is most likely not to be the best fit for the organization. Similarly, if the selection is made by the purchasing department based on the lowest bidder, it is likely that the CMMS selected will not be adequate to support the overall needs of the maintenance department.

Selecting the most appropriate CMMS must be an organized and precise effort. It should be driven by the goal of implementing a system that will enhance the reliability of equipments, reduce maintenance budget and increase overall profitability of the company. The basic steps involved in selecting the right CMMS system (Call, 2003), are:

- Create a multi-departmental CMMS selection team.
- Determine the right features and functionality required.
- Develop a detailed CMMS specifications document.
- Get proposals from many vendors and review their proposals.
- Select a few vendors who can meet the requirements.
- Expect these vendors to demonstrate their systems.
- Evaluate, select and implement the right CMMS system.

This research focuses on developing guidelines to help in determining the right features and functionality required in a CMMS system - based on the needs of the organization. The research objective is to create guidelines to select the right CMMS, by developing an application (SELECTCMMS) in Visual Basic. SELECTCMMS will list out the various features and functions currently available in many CMMS systems. In a CMMS system, many different "Modules" (example: Equipment module, Work order module, etc.) are utilized to plan, schedule, execute, track and control the equipment maintenance. Each module has various features and functions that determine how efficiently CMMS systems are utilized for cost efficient maintenance management. Using SELECTCMMS, the CMMS selection team can select all the features and functions needed for cost efficient maintenance. A detailed CMMS specifications document in Microsoft Word is
automatically created, based on the features and functions selected. This detailed CMMS specifications document can be utilized to solicit proposals from different vendors to evaluate, select and implement the right CMMS system to enhance the reliability of equipments, increase productivity of maintenance department and generate higher profits for the organization.

It has also been reported that many companies who currently utilize a CMMS for maintenance; the usage rate of the available features for their existing CMMS is extremely low - only around 30% (Parker, 2003; Singer, 1999). There is tremendous opportunity to improve the usage rate of the features and functions already existing in their CMMS to enhance the maintenance productivity. Additionally, SELECTCMMS can be used to conduct an internal survey to determine the features that are currently being used and the features that are being missed out. This will greatly help the company to increase the usage of their existing CMMS features, which in turn can lead to significant improvement in maintenance productivity, enhance the reliability of equipments and generate higher profits.

Significance of this Research

For many organizations, the effectiveness of maintenance can make a huge difference between success and failure. Many companies consider their CMMS system and innovative maintenance programs as catalysts for achieving a competitive advantage. CMMS have evolved over the last three decades from simple maintenance documentation software to Enterprise Maintenance Management System. When properly selected and implemented, CMMS can greatly assist in maintenance planning and scheduling, manage personnel and materials, track maintenance work order and history, develop detail cost reporting and budgeting and much more. In general, these
systems provide comprehensive features and functionality to efficiently manage and track all maintenance related activities.

However, selecting and implementing the right CMMS system is not an easy task. There are hundreds of vendors providing solutions on a variety of platforms. With more than 200 CMMS systems to choose from, selecting and implementing the right CMMS based on the operations and maintenance requirements of a company can be a daunting task. However, by creating detailed system requirements that match the company's operations and maintenance processes, one can ensure a proper fit. Developing detailed requirements based on all available features in each CMMS modules, can allow better opportunities to ensure the best fit. This approach also reduces the need to customize the software, and the return on investment (ROI) can be faster as the system is implemented with greater opportunities for full usage. There are few (if any) surprises, because every possible feature of the software has been carefully scrutinized before selection. This approach helps to create a strong foundation for acceptance by all the employees who would ultimately be in charge of using the system to improve reliability of equipments and enhance the maintenance productivity.

**Methodology and Limitations**

In a CMMS system, many different “Modules” (Ex: Equipment module, Inventory module, Personnel module, Work Order module, Reporting module, etc.) are utilized to plan, schedule, execute, control and track maintenance related activities. Each module provides various features and functions that determine how efficiently a CMMS system is utilized for cost efficient maintenance management. Depending on the maintenance and operational requirements of the company, many features and functions in each of these modules should be carefully evaluated and selected. It is important that these features and functions will support all maintenance related activities. The maintenance process
and the software features must be compatible to perform the maintenance function smoothly and effectively. It is also important that the CMMS selected is user friendly and helpful to everyone who will use or interact with the system. (Ex: maintenance requester, maintenance planner, maintenance manager, maintenance engineer, maintenance technicians, production managers, production operators, etc.)

In order to determine the various features and functions available in the CMMS systems, several CMMS systems currently available in the market were reviewed and researched. (For a complete list of CMMS systems researched and reviewed for this research, please refer to APPENDIX A). After researching several CMMS systems, a detail list of features and functions were developed for every module in the CMMS system. Each CMMS module has a separate list of features, specifically dealing with that particular module. For example, these are some of the features and functions listed in

**Work Order (Assign Personnel)**

- Able to match personnel skills to tasks to be performed in the work order
- Able to automatically update employee schedule once their name is added to work order
- Able to link employee time sheet hours and their detail schedule to work order
- Able to automatically email, once name of employee is added to the work order
- Able to see detail schedule and balance workload using graphical interface

**Work Order (Reserve Materials)**

- All needed materials and spare parts can be listed and reserved for work order
- Able to flag certain parts or materials as 'hazardous material' in the work order
- Able to see parts status from work order screen before and after reserving parts
- Able to select new, used or reconditioned parts from within the work order screen
Able to view the stock levels of every part from within the work order screen
Able to select parts from multiple warehouses from within the work order screen
Able to receive unused parts back to the stores/warehouses and stock levels can be adjusted

The format of the questions will provide the user with four options to choose from
- Must Have,
- Important,
- Nice to Have,
- Not Important

The CMMS selection team can review all the features listed in SELECTCMMS and make their selection (Must Have, Important, Nice to Have, Not Important) based on the requirements of their company.

The following details were reviewed to decide which software (Ex: Microsoft Word, Microsoft Excel or Visual Basic) should be used to create SELECTCMMS application to make CMMS selection more organized and systematic.
- Able to create a good user friendly interface, which is easy to use
- Able to correctly enter detail features and functions currently available in different CMMS modules
- Able to easily “pick and select” any needed feature and function by clicking - Must Have, Important, Nice to Have, Not Important
- Able to easily “organize and keep separate” different Modules - Work Request module, Equipment module, etc.
- Able to easily “Go back and forth” between the different Modules - Inventory module, Purchasing module, etc.
- Able to easily create a “CMMS Specifications document” in Microsoft Word based on the features selected
- Able to easily add additional information by the end user to the CMMS specifications document

To create SELECTCMMS, Visual Basic software was used, as it would fulfill all the above requirements.

**Limitations of this Research**

Many CMMS systems currently available in the market are very expensive and cannot be easily accessed. Therefore, it was not feasible to review and research the actual CMMS systems, in order to collect the information about the available features and functions. Detail information on CMMS features and functions were collected by reviewing and researching various CMMS company websites, CMMS users manuals and demo version of the actual CMMS systems. Many CMMS company websites and users manual provide significant amount of information regarding the features and functionality available in their CMMS systems. Some CMMS companies do allow downloading the demo version of their CMMS software. For a complete list of CMMS systems researched and reviewed for this research, please refer to APPENDIX A.

This research helps in creating a Specifications document, which can be used to select and implement the right CMMS system, based on the needs of the organization. This research does not determine or tell the user, which specific CMMS system should be selected for their organization.
LITERATURE REVIEW

History of Maintenance

Before we understand the modern maintenance practices and programs, it is important to look at the history of maintenance. Since ancient times, there has always been a need for maintenance of equipments. In the period up to and shortly after the First World War, equipments were generally simple and robust. The ways it could fail were easily treated, since the simplicity of the equipment design helped to diagnose the problem easily and in many cases, equipment failure was an acceptable reason for loss of production. In this situation, maintenance was usually performed when the equipment failed and could no longer be used to perform its intended function. This type of maintenance is called as Breakdown or “Corrective Maintenance”.

![Figure 1: Historical View of Maintenance (Visser, 2002)](image)
**Breakdown Maintenance**

Breakdown maintenance is sometimes known as "reactive maintenance" or "corrective maintenance". The costs of corrective maintenance are relatively high because of unplanned downtime, damaged machinery, and overtime expenditure. For this type of maintenance, the production and maintenance departments are controlled by the uncertainties of their machines, and the actual status of the overall plant machinery is only vaguely known. This makes it nearly impossible to plan for maintenance needs and is extremely difficult to predict the state of overall system readiness. Corrective maintenance needs to be a very small part in a modern maintenance program, but there are some instances where it does make sense. An example is a plant, which employs a great number of similar machines that are not expensive to replace or to repair. When one breaks down, others can take up the slack and production is not affected very much.

**Preventive Maintenance**

During the Second World War, things began to change and the availability of manpower declined in many industrialized nations of the time. Equipment became more complex, thus replacing the need for manual intervention and reducing manpower requirements. Loss of production through equipment failure also became unacceptable leading to work on prevention of failures before they occurred. Conventional wisdom suggests that as equipment gets older it "wears out" and becomes more likely to fail. Using this model, it was believed that failures could be avoided if equipment was maintained or overhauled before items "wore out". All that had to be determined was the "right time" or "right age" for overhaul. This new trend was called "Preventive Maintenance".

Preventive maintenance is sometimes also called as "historical maintenance" due to the fact that the histories of each machine type are analyzed and periodic
overhauls are scheduled before the problems occur. It has been understood that most groups of similar machines will exhibit failure rates that are somewhat predictable if averaged over a long period of time. This gave rise to the so-called "Bathtub Curve" which relates failure rate to the operating time, as follows.

![Bathtub Curve for Preventive Maintenance](image)

**Figure 2: Bathtub Curve for Preventive Maintenance**

The "Bathtub curve" is also known as "wear out" model or "right age" model. The break-in period, also known, as "infant mortality period" is the initial phase of the newly installed machine (or overhauled machine) where the probability of failure is high. As the machine is used over a period of time, the probability of failure decreases and stays relatively constant during normal operation period. The normal operation is also known as "useful life period" where the machine exhibits a relatively low and constant failure rate. During the "Wear Out", period the failure rate starts to increase rapidly. When the failure rate becomes high, replacement or major repair must be performed, if the machine is to be left in service. If this curve applied to all machines of the group, and if the shape of the curve is known, preventive maintenance could be used advantageously for many different machines. Although this type of maintenance helped to reduce downtime, it was still an expensive alternative. The reasons being that many parts were replaced on a time basis, while they could have lasted much longer making it very expensive. Also in many cases overhauling at the "right time" did not prevent the
machine from breakdown or failures. This helped to look at different methods of preventing failures.

*Reliability Centered Maintenance*

The growth of civil aviation in 1950's triggered the next step. At about the same time the Federal Aviation Administration (FAA), the department responsible for regulating airlines in United States was worried about aircraft reliability. In an effort to reduce the number of failures, the frequency of scheduled maintenance (based on "wear out" model) was increased. This lead to higher maintenance costs which by the late 1950's prompted the industry to look at the concept of "Preventive Maintenance". It became obvious that too much emphasis had been placed on the 'wear out' model. A task force was created to critically review and analyze the "wear out" model. This task force developed a new system of reliability program and created a new maintenance document (called MSG-3) that could be used for aircraft maintenance. This maintenance document (MSG-3) began to be widely used by all airlines to maintain their various aircrafts. During 1980's, this document (MSG-3) was reviewed by other industries and eventually accepted as an excellent method to enhance the reliability and maintainability of equipments. Outside airline industries, the application of MSG-3 was generally known as Reliability Centered Maintenance (RCM).

Basically, the RCM methodology addresses key issues not dealt with by other maintenance programs. This approach recognizes, that all equipments in a facility are not of equal importance - to either the process or to production needs and employee safety. Focusing on reliability of equipment means, recognizing that equipment design, function and operations differ (in the context of overall plant productivity) and that each piece of equipment will have a different probability of developing failure due to normal use or wear-out. A reliability centered approach will mean structuring a maintenance
program based upon the understanding of equipment needs and priorities. With many organizations having limited financial and personnel resources, it is important to plan activities such that equipment maintenance is prioritized while operations are optimized. There are several articles and books that discuss the methodology of Reliability Centered Maintenance.

**Total Productive Maintenance**

Unlike Reliability Centred Maintenance (RCM), which evolved from the United States airline industry, Total Productive Maintenance (TPM) originated in 1970s from the Japanese car industry. It evolved at Nippondenso (Now called as Denso) a major supplier of the Toyota Car Company, as a necessary element of the newly developed Toyota Production System.

TPM can accomplish more effectively, what other maintenance and quality improvement efforts cannot. The goals of TPM are to move towards zero breakdowns, zero defects, and reduced costs for maintenance. To accomplish these goals, the three phases of the equipment's life span are carefully observed. The first phase is the acquisition or start-up stage. The second phase, the operational stage, deals with operating and maintaining the equipment in the best possible manner. The last phase, the wear-out stage, is the period when the equipment's performance is affected by wear and tear. Equipment Improvement Teams (from many different departments) are used during all three stages. These teams help in the design of new equipments, assist the operator in conducting basic equipment care and inspection activities, and also identify and eliminate the causes to equipment failures. Since the early 1990s, TPM has rapidly spread throughout the western world, significantly improving the availability, productivity, quality, delivery, safety, morale and profits in many manufacturing and other industries. TPM is also having a major impact on revitalizing and enhancing previous quality
management or continuous improvement initiatives. There are several books and articles written on the topic of Total Productive Maintenance.

**Condition Based Maintenance**

The next improvement in maintenance technology was the advent of Condition Based Maintenance (CBM), which is based on the determination of a machine's condition while in operation. Condition based maintenance is sometimes known as "Predictive Maintenance". Basically this type of maintenance differs from preventive maintenance by basing maintenance needs on the actual condition of the equipment, rather than on some predetermined schedule. The technique is dependent on the fact, that most machine components will give some type of warning before they fail. To clearly sense the symptoms by which the machine is giving out any warning signal, requires conducting several types of non-destructive testing, such as vibration analysis, oil analysis, wear particle analysis, temperature measurements, etc. Use of these techniques to determine the machine condition results in a much more efficient use of maintenance effort compared to any earlier types of maintenance.

Condition based maintenance allows maintenance management to control the machinery and maintenance programs, rather than machines controlling the maintenance programs – like in corrective maintenance. In a plant using condition based maintenance, the overall machinery condition at any time is usually known and more accurate and efficient maintenance planning is possible. There are several books and articles written on the topic of Condition Based Maintenance.

**Computerized Maintenance Management System**

In the earlier days, maintenance was usually performed when an equipment needed maintenance, but very little of it was ever documented. As maintenance needs and
programs like RCM, TPM and CBM evolved, the need to document the maintenance related activities became more important. During 1970s and 1980s, most of the documentation had to be done manually before the advent of the personal computers (PC). Creating and maintaining this documentation was very inefficient and very time consuming. With the advent of personal computers in the early 1990s, companies started using them to document the maintenance related activities, which proved to be very efficient. During the same time, some vendors started developing Computerized Maintenance Management Systems (CMMS) that provided companies an efficient tool to not only to document, but to plan, schedule, document, control and track all maintenance related activities. CMMS helped several companies to reduce their maintenance expenses, improve their productivity and enhance their equipment reliability. Due to the huge demand and popularity of CMMS, the number of vendors providing this software considerably increased (more than 200), making it very difficult for the companies to select and implement the right CMMS based on their companies requirements.

**Role of Maintenance**

For a company to be successful in today's highly competitive global economy, it is extremely important to achieve and maintain a very high level of quality and productivity. To maintain a high level of quality and productivity, it becomes imperative that the equipments that are used to produce these products are very reliable and are maintained in excellent working conditions.

But in reality, equipments can malfunction or breakdown due to a number of reasons. For example, due to poor equipment design, incorrect components, incorrect fabrication and assembly, improper usage of the equipment, ineffective preventive maintenance, etc. The untimely failure of any equipment can cause major inconvenience to production or can cause total shutdown of the production system. Under these
circumstances, every minute counts and the time to repair the equipment and bring it back to production will be of utmost importance. The time to repair the equipment can be shortened to a great extent, by having good documentation of similar problems in the past. Also, by maintaining good documentation, many other factors can be achieved. Preventive maintenance programs and other maintenance programs like TPM, RCM and CBM can be setup, so that untimely equipment failure can be minimized or eliminated. Good documentation can be used by the equipment designer to avoid similar problems in future designs. Proper documentation can help the machine operator to better understand any potential problems the equipment may have, watch for them if they arise and report it to maintenance before the machine breaks down. With careful documentation, many reliability and maintainability reports can be generated, which can help to keep the equipment in good working condition. Equipment downtime, potential loss of production, maintenance cost and any other cost can be tracked and reports can be generated, which can help to prevent or minimize such occurrences. So we understand that, proper documentation of equipment failure and corrective action is very critical.

With several companies facing global competition, they are looking for potential areas or departments to gain a competitive edge and increase their productivity and profits. The field of maintenance promises to be one area with great potential to increase productivity and generate higher profits. For many companies maintenance, repair and operations (MRO) has emerged as a prime candidate for improved cost savings and enhanced productivity and profits (Schulz, 2001).

“There is no doubt that maintenance remains one of the very few business areas where significant increases to company profits can be achieved”

- Thomas, C., 2002
Maintenance plays a very important role in the overall profitability of a company. Maintaining and managing the asset of a company is usually the responsibility of the maintenance department. Maintenance can increase or decrease the profitability of the company as no other function in a company affects overall productivity and profitability as much as maintenance does. Maintenance keeps equipments and processes working reliably, thereby enabling the production personnel to be efficient and productive. Along with keeping equipments in good reliable working condition, many other functions in the organization are dependent on maintenance. Quality assurance, On-time delivery, energy conservation, employee safety, inventory control, regulatory compliance, continuous improvement and total asset management are all maintenance dependent.

To efficiently maintain and manage the assets of a company, the maintenance department should have an effective maintenance management process. In general, maintenance management deals with developing good maintenance strategies (based on business needs) and implementing these strategies utilizing available resources. Visser (2002) has provided a list of five important managerial functions that need to be carried out for effective maintenance management process. They are planning, organizing, staffing, leading and controlling of all the maintenance tasks in the company. These five managerial functions are critical in establishing maintenance objectives (based on business objectives) and implementing them to achieve the business goals.

Along with having good maintenance management process, it is also important to have a long term maintenance strategy. Just like many departments in the company have strategies for long term growth, maintenance should be viewed as a profitable center and a long term strategy should be developed. Murthy (2002) has provided two key elements of developing a strategic maintenance approach. They are:

- Maintenance management should be considered as a core business activity crucial for survival and success of business and must be managed strategically
Maintenance management should be based on quantitative business models that integrate maintenance with other decisions such as operations and production. Business situations change and in the climate of global competition, this is inevitable. So just like many other strategies in the company, maintenance strategies should be carefully evaluated and improved continuously to reflect the changing business environment. Raouf and Ben-Daya (1995), have proposed that the current situation of the maintenance should be comprehensively audited and using this information, potential areas should be identified for improvement. This should be performed on a regular basis, so that the maintenance strategy is always in-line with the company’s overall goals and objectives. The productivity of maintenance department is usually more difficult to measure, compared to other departments. For example, productivity of production department can easily be measured based on the total number of products produced. In case of maintenance, value added and non-value added activities need to be clearly distinguished for measuring the productivity of maintenance department. Bleazard (2001) mentions that value added activities for maintenance include functions like predictive and proactive maintenance and technician training that will help to improve overall productivity. Bleazard (2001) suggests that non-value added activities like reactive maintenance and unnecessary preventive maintenance should be minimized or eliminated to drastically improve the productivity of maintenance.

With businesses facing global competition, several companies are looking at ways to cut cost and boost productivity and profits. To survive and succeed in such turbulent environment, outsourcing of products and services has become common place. However, outsourcing of maintenance related activities is not an easy decision for many companies. Unlike products and services, maintenance function has a few unique features that make it difficult for outsourcing. In general, maintenance needs to be performed according to a certain schedule (preventive or predictive, etc.) that prolong
the life of the equipments. Even though these schedules can generally be planned well ahead of time, but having maintenance employees available on hand gives the company more flexibility and makes it easier to plan, schedule and perform maintenance tasks based on the availability of the equipments and on the skill levels of the available employees. The advantage of having skilled maintenance employees internally, can greatly help them to learn more about the equipment problems and rectify them before they become a major source of downtime, losing thousands of dollars worth of production. Tsang (2002) has provided a few strategic issues that can determine if any of the maintenance activities can be outsourced or should be performed internally. It looks at several factors like cost, quality, efficiency, maintaining competitiveness, gaining and retaining knowledge, strength and weakness of the supplier and a few other factors. In general, Tsang proposes not to outsource any maintenance activities that are crucial and form the core competencies of the company.

The challenge for today's maintenance managers, reliability professionals, and all those involved in the maintenance profession, is to ensure that maintenance is not regarded as a necessary cost for doing business, but a profit making business unit. This requires establishing efficient maintenance strategies, selecting, implementing and integrating the right computerized maintenance management system (CMMS) based on the organizations requirements. Therefore, the integration of advanced maintenance strategies and implementation of the right CMMS system can greatly benefit maintenance and significantly increase the competitive advantage of the company.

However, one of the most common barriers to implementing any change to a maintenance strategy or implementing the right CMMS system is poor comprehension of maintenance related issues by the senior management. The findings from a recent Intentia EAM Survey, (2003) that looked at maintenance of plant, equipment, facilities and assets, revealed that a "fix it when it's broken" attitude is prevalent among many
organizations, potentially costing millions of dollars annually. Almost 85% of organizations surveyed, agreed that preventative maintenance increases productivity and return on assets, yet only around a third spent more than half of their maintenance budget on preventative maintenance strategies.

Even though the Intentia EAM Survey (2003), did not include any companies from North America, but targeted over 470 manufacturing, equipment and plant type organizations in Australia, Asia and Europe, some of these findings can be relevant to companies in North America.

The results also showed that there is lack of awareness by management on issues relating to maintenance and several benefits that can be gained by an integrated approach using advanced maintenance strategies and computerized maintenance management systems. One in eight respondents indicated that their annual loss of production, due to plant equipment failure, exceeded $500,000. Also a third of organizations with more than 1000 employees experienced an annual maintenance-related loss of production of more than $500,000 - most of which could probably be avoided using the right maintenance strategy and the right CMMS system. Only half of the survey's respondents (49.8%) indicated that maintenance was considered as an investment while the remaining half (50.2%) considered maintenance as a cost of doing business.

This reveals that maintenance professionals need to work more closely with the senior management to establish the investment case for maintenance system improvements. They also need to effectively communicate the potential benefits that an efficient maintenance strategy and computerized maintenance management system (CMMS) can provide their organization. In order to ensure that maintenance is not regarded as a necessary cost of doing business, but as a profit making business unit; maintenance managers need to emphasize the need to calculate the return on
investment (ROI) and then sell those benefits to the decision makers in their organizations. A computerized maintenance management system (CMMS) will be a great tool to achieve the above objectives, which will greatly help to enhance the reputation of maintenance department in the organization.

Role of CMMS

The main reason for selecting and implementing the right Computerized Maintenance Management System (CMMS) is to improve maintenance productivity, reduce maintenance expenses and to enhance reliability and maintainability of equipments through effective planning, scheduling, executing, tracking and controlling the maintenance activities. In the early days of CMMS, there was an expectation that introducing the new technology alone would provide the promised benefits. Many companies expected instant results by introducing a CMMS and expected that their employees would adapt their work practices to make optimum use of this new technology.

More recently, it has been recognized that, while CMMS can be a significant tool for improved maintenance performance; in order to achieve the maximum possible benefits from a CMMS implementation, maintenance processes and procedures must be updated or changed in a coordinated and planned manner for smooth running of maintenance and operations. No computerized maintenance management system (CMMS) will be effective, unless a systematic process is developed for planning, scheduling and tracking the maintenance work. Once established, this process must be followed consistently if significant results are to be expected. It is also important that the operations and maintenance departments decide whether the features and functionality of the CMMS being selected will match the company's maintenance procedures or whether the maintenance procedures will be updated or modified to fit with the CMMS
system (Autin, 1998). This can greatly help in deciding and selecting the right features and functions needed for the existing or modified maintenance procedures.

Prior to 1970, there was little focus on identifying and managing the maintenance function. The primary focus was on direct manufacturing, operations and materials. Generally, maintenance was looked upon as a cost of doing business. During the period from 1970 to 1980, some focus on documenting maintenance, especially with reference to preventive maintenance and equipment uptime began to happen. Also during this time, there were initial attempts to define and establish business processes supportive of maintenance, which were further enhanced by the development of computer tools like, computerized maintenance management systems. These were the initial attempts to use computerized maintenance management systems (CMMS) to track equipment maintenance and preventive maintenance.

However, computerized maintenance management systems (CMMS) have evolved over the last three decades from simple documentation of maintenance related activities, to enterprise maintenance information systems. Ten years ago, there were just a few major CMMS software companies, and the state of technology was such that no single package was able to meet all the requirements of any one customer. Each vendor would attempt to show that its product met more of the customer's requirements than the others did. Where requirements were not met, the vendor would propose custom modifications or third party add-on packages.

Now, there are hundreds of vendors providing solutions on a variety of platforms. These systems provide the users with comprehensive features and functionality to facilitate the flow of maintenance information and the ability to check the status of the maintenance organization. The CMMS/EAM trends are moving from corrective maintenance to preventive maintenance and other maintenance programs (like RCM, TPM, CMB) increasing management level capabilities such as key performance
indicators, reports and analysis, integration with other applications, mobile access and business intelligence systems (Singer, 2003).

The CMMS/EAM industry is expected to grow at a rate of 5.3% annually, over the next five years. In addition, it is expected that the industry revenues will reach $1.6 billion by 2006 (Smith, 2003). This expected growth does indicate good health and great potential for such a mature industry.

In recent years, several new trends are appearing in the CMMS/EAM industry. Mobile or hand held (palm pilot) units are gaining popularity (Smith, 2002) due to the fact that maintenance technician does not have to waste time in coming back to their computer terminal and can easily access the needed information right on their mobile unit. It also reduces the paper work (no need to print work orders) and maintenance information will not be lost and can be updated immediately (after completing the maintenance work). Another advantage of mobile unit is that the maintenance manager can send an emergency work order to any technician in the field without having to waste any time in trying to contact them. This helps the maintenance team to be more agile and efficient, thereby improving their productivity.

As the maintenance, repair and operations (MRO) software market continues to expand; many vendors have developed solutions that focus on specific segments of asset and work management. Systems described as enterprise asset management, asset life cycle management, asset performance management, asset or enterprise reliability management and condition monitoring are all focused on achieving the same goal, - increasing equipment availability and performance, increasing product quality and reducing maintenance expenses. When the right CMMS is selected and properly implemented to facilitate established maintenance process and standards, those goals can be effectively realized.
CMMS SELECTION GUIDELINES

Selection Guidelines

The transition from a manual maintenance management system (or replacing an existing CMMS system) to a computerized maintenance management system (CMMS) will require a substantial investment, both in terms of capital and time. The return on this investment (ROI) will be dependent on efficient maintenance procedures, suitability of the selected software package, effectiveness of its implementation and the commitment of all personnel involved to the new system.

Selection and implementation of a CMMS is most successful in organizations that have committed to a long-term maintenance strategy, based on efficient maintenance practices and procedures. A CMMS provides an effective tool to integrate good maintenance strategies and to lead and manage maintenance as a key part of the total maintenance and operations management.

One of the most important things, when selecting a CMMS is to use the team approach. Many authors in several articles have proposed this method (Trunk, 2001; Tiewater and Graham, 2001; Singer, 2000). This team must include representatives from each functional area of an organization that might use or interact with the system, as well as a member of the Information technology department to advice on the CMMS database and integration with other existing systems.

Typically, with the maintenance manager leading the team, the team should include maintenance engineers, maintenance supervisors, maintenance planners, facilities managers, plant managers, production managers, plant engineers, members of the maintenance workforce, members from the purchasing department, members from the inventory storeroom and anyone else who has a stake in the selection and
implementation of the system. The senior management should be consulted and their input should be taken into account in order to get their buy-in into the system.

In a CMMS system, many different "Modules" are utilized to plan, schedule, execute, track and control the equipment maintenance, including the personnel, inventory and purchasing management. Each module has many different features that determine how efficiently CMMS systems are utilized for effective maintenance management. Depending on the operations and maintenance requirements of the company, many features in each of these modules should be carefully evaluated. Many of these modules have features, which not only affects that particular module, but can affect many other modules. So careful attention need to be provided so that the features selected will be helpful to the overall maintenance management. For most organizations, the primary areas of focus are system security, system integration (with existing systems), software compatibility, database system, work request module, work order module, equipment module, personnel module, preventive maintenance module, inventory module, purchasing module and reporting module. Virtually all aspects of a maintenance department's work can be managed by the modern integrated software packages. These can have many options, which may be chosen according to the user's requirements. Many vendors supply their software in a modular fashion. Companies can then select only those "Modules", which are suitable for their organization.
Justify Need for CMMS

The first and a very important step during the selection of any CMMS system, is to clearly define and justify the need for CMMS and the benefits of implementing a CMMS system. During this process, it is also important to determine the expectations of implementing a CMMS system and the return on investment (ROI). Many problems can be avoided by clearly defining the need and benefits of CMMS implementation at the company. CMMS systems are extremely expensive to implement and it is very important that all stakeholders are fully aware of what they will get, in return for the investment (both in terms of time and money). Sometimes this important step may not be well defined (for example: one of the top management may have attended a seminar or conference and without getting into further details, he/she may propose that their company should invest in a CMMS to make it competitive in the global economy).

Detail functional requirements and total system requirements should be clearly defined and agreed upon by the selection team. The need for CMMS should be based on realistic expectations on how the CMMS system will meet the maintenance, operations and business needs of the company. A CMMS selection team should be formed and the team members must communicate effectively to understand the details on how the maintenance, operations, inventory, purchasing, and other relevant departments work and interact with each other. The selection team must understand the existing maintenance practices and procedures, the process workflow in the company and all business processes that interact with the maintenance department. During the process of CMMS selection and implementation, the selection team should be open to new ideas and always look for ways on improving the existing process workflow and maintenance procedures.
There are several reasons on why an organization wants to select and implement a CMMS system. Detail requirements of the features and functions should be carefully reviewed before the selection of the CMMS system. However, it is extremely important to clearly define them, so that not only these reasons are going to be the focal point during the selection process, but also during and after the implementation. Some of the reasons for implementing a CMMS are:

- Improve the reliability and availability of equipments
- Increase the life of equipments by efficient maintenance
- Setup an efficient Preventive and/or Predictive Maintenance programs
- Setup an efficient Reliability Centered Maintenance (RCM) programs
- Reduce the percentage of corrective maintenance work orders
- Increase the percentage of preventive maintenance work orders
- Reduce maintenance expenses and enhance maintenance productivity
- Have better control over inventory and reduce inventory expenses
- Have better control over the short term maintenance schedule
- Have better control over the long term maintenance schedule
- Able to predict and manage maintenance budget accurately
CMMS Main Modules

There are many different modules in a CMMS system for cost efficient maintenance management. The Main Modules in many CMMS systems are

- Work Request Module
- Work Order Module
- Equipment Module
- Personnel Module
- Preventive Maintenance Module
- Inventory Module
- Purchasing Module
- Reporting Module

![Diagram showing relationships between CMMS Main Modules]

Figure 3: Relationships between CMMS Main Modules

The above figure shows the "typical relationships" between the Main Modules in the CMMS system.
CMMS Optional Modules

There are many other modules (Optional Modules), which help to enhance the effectiveness of the CMMS system. Very few CMMS systems currently available in the market today, contain all of these optional modules. In a few CMMS systems, some of these optional modules are integrated with the main modules. (E.g. Warranty Module is integrated into the Equipment Module, Security Module is integrated into Personnel Module, etc.). These optional modules should be carefully evaluated and selected based on the requirements of the organization. The different optional modules commonly used in many CMMS systems are:

- Analysis Module
- PDA Interface Module
- Security Module
- Scheduling Module
- Vendors Module
- Receiving Module
- Document Module
- History Module
- Warranty Module
- Web Browser Module
CMMS General Requirements

Apart from evaluating many of the CMMS modules, some of these general requirements should be carefully evaluated for CMMS selection. These are some of the general requirements that should be considered and evaluated for selecting the right computerized maintenance management system (CMMS).

Hardware Requirements
  - Minimum Required
  - Recommended

Operating Systems
  - Minimum Required
  - Recommended

Database Systems
  - Microsoft Access
  - Microsoft SQL Server
  - Oracle System
  - Any Other Systems

Number Of Users
  - Stand Alone
  - Client/Server

Interface with other systems
  - ERP Interface
  - PDA Interface
  - Barcode Interface
  - Web Based Interface
  - MS Project Interface
o Any other Applications

Other Important Details

o Multiple Site Capability

o Ease of Customization

o Ease of Navigation

o Languages Supported

o Currency Supported

o Multiple Database Support

o Security of the System

o Regulatory Compliance

o Implementation Support

o Training provided

o Support and Service

o Years in Business

o Future Enhancements

Company and other department details should also be carefully evaluated for selecting the right CMMS for the organization. Some of the main ones are

o Assets, Production, Process and Facilities details

o Company and Maintenance department structure

o Existing Manual Maintenance system details

o Information department structure and available support
User Guide for SELECTCMMS

Selecting the right CMMS system can greatly influence the overall success of the CMMS implementation. However, selecting and implementing a CMMS is not a simple or an easy task. There are several challenges, which can very easily result in a failed implementation. The final selection should be based on the right features and functions available in a CMMS system, which compliment the maintenance practices and procedures of the organization.

To select the right features and functions in a CMMS system, a CMMS Selection Tool (known as SELECTCMMS) was developed in Visual Basic 6.0. A brief description is provided here on how SELECTCMMS application can be used to select the right features and functions needed in the CMMS system, based on the requirements of the organization. The CMMS selection team can use SELECTCMMS to review all the available features and functions in each of the modules and then select the right features needed, which are going to be compatible with the existing (or improved) maintenance practices and procedures in the organization. Using SELECTCMMS, a detailed specifications document in Microsoft Word can automatically be created based on the features and functions selected. This detailed specifications document can be utilized to solicit proposals from different vendors to evaluate, select and implement the right CMMS to enhance the reliability of equipments, increase productivity of maintenance department and generate higher profits for the organization.
**CMMS Home**

This is the opening screen, known as "CMMS Home" (shown below) that is displayed once SELECTCMMS application is opened. The CMMS Home page displays names of the people involved in developing SELECTCMMS application. This screen can be displayed anytime, by clicking "CMMS Home" on the Menu Bar.

![CMMS Home Screen](image)

**Figure 4: CMMS Home Screen for SELECTCMMS**

A "Menu Bar" is provided to access different menus, specific to this application. The different menus listed on the "Menu Bar" are as follows - CMMS Guidelines, General Requirements, Main Modules, Optional Modules, Create Specifications, CMMS Home, CMMS Help, CMMS Exit. More details on these menus are provided below.
CMMS Guidelines

The “CMMS Home” page provides a link to “CMMS Guidelines”, which gives more information on the importance of SELECTCMMS application. The “CMMS Guidelines” screen (shown below) can be displayed either by clicking this link (on CMMS Home page) or by clicking “CMMS Guidelines” on the Menu bar.

![CMMS Guidelines Screen](image)

Figure 5: CMMS Guidelines Screen for SELECTCMMS

This screen provides detail information on the need and importance of using SELECTCMMS to select the right features and functions in a CMMS system, based on the company’s requirements. Detailed requirements based on all available features and functions in each CMMS modules, will allow for better opportunities to ensure a proper fit...
with the maintenance and operational requirements of company. (Refer SELECTCMMS application for more details.)

**CMMS Help**

The "CMMS Help" screen (shown below) can be displayed by clicking "CMMS Help" on the Menu bar. This screen provides detail information on how to use the SELECTCMMS application to select the right features and functions in the CMMS system.

![CMMS Help Screen](image)

**Figure 6: CMMS Help Screen for SELECTCMMS**

CMMS help screen can be displayed anytime (from any screen) by clicking on the "CMMS Help". The CMMS help screen is displayed on top of any open screen, making it easier to review this help information whenever needed. This help screen provides details on how to use this CMMS selection tool.
**General Requirements**

The CMMS "General Requirements" screen (shown below) can be displayed by clicking "General Requirements" on the Menu bar. Apart from evaluating many of the CMMS modules, some of these general requirements should be carefully evaluated for selecting the right computerized maintenance management system.

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**Operating Systems**
- Minimum Required
- Recommended

**Database Systems**
- Microsoft Access
- Microsoft SQL Server
- Oracle System
- Any other Database

**Number of Users**
- Stand Alone
- Client/Server

**Modular Design**
- Main Modules
- Optional Modules

**Programming Language Used**
- Visual Basic
- Power Builder
- C++
- Other Language

---

**Figure 7: General Requirements Screen for SELECTCMMS**

The information provided on this screen (General Requirements screen) is automatically added to the "CMMS Specifications Document" (created in Microsoft Word) when "Create Specifications" menu is clicked on the Menu Bar. This Microsoft Word document (CMMS Specifications document) can be modified or updated, based on the requirements of the company.

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Main Modules

The "Main Modules" in the SELECTCMMS contain these eight Main Modules: Work Request module, Work Order module, Equipment module, Personnel module, Preventive Maintenance module, Inventory module, Purchasing module and Reporting module.

![Main Modules Screen for SELECTCMMS](image)

Figure 8: Main Modules Screen for SELECTCMMS

Each module lists out many features and functions, specific to that module. For example:

The "Work Request Module" screen (shown below) can be displayed by clicking "Main Modules" and then clicking "Work Request Module" on the Menu bar. Each module provides detail list of many features and functions, available in the CMMS system. For example, in the "Work Request Module", some of the features and functions listed are:
- Reasons for the equipment failure, can be entered or selected from a dropdown list in the work request.
- Able to specify when the equipment will be available (date and time) for maintenance purposes.

For every feature and function listed, the user is provided with four options to choose from (please refer the screen below):

- Must Have
- Important
- Nice to Have
- Not Important

![Figure 9: Work Request Module Screen for SELECTCMMS](image-url)
After reviewing each feature and function, the user can make the selection based on the requirements of the organization. For Example: after reading a feature, the user can select “Must Have”, if this feature is extremely important for the organization.

Some of the features listed in SELECTCMMS, may need additional information before the user can make a selection. For better understanding of these features, “Help” commands are provided (next to the feature). For example, by clicking “Help” next to the feature (refer below) additional information regarding the “Equipment tree view” (In Equipment Module) is displayed in a new pop-up window. Help commands can be clicked to gain additional information of the listed feature, before making the selection. (Must Have, Nice to Have, etc.)

Figure 10: Additional Help Screen for SELECTCMMS
Optional Modules

The "Optional Modules" in the SELECTCMMS contain these four optional Modules: PDA Interface module, Analysis module, Security module and Scheduling module. The below screen shows the "Analysis Module" screen in the optional module.

![Optional Modules Screen for SELECTCMMS](image)

Figure 11: Optional Modules Screen for SELECTCMMS

Similar to the Main modules, each optional module lists out many features and functions, specific to that module. For example: The "PDA interface Module" screen (shown below) can be displayed by clicking "Optional Modules" and then clicking "PDA interface Module" on the Menu bar. Each module provides detail list of many features and functions, available in the CMMS system.
Similar to the Main modules, for every feature and function listed in the optional module, the user is provided with four options to choose from (please refer the screen above):

- Must Have
- Important
- Nice to Have
- Not Important

After reviewing each feature and function, the user can make the selection based on the requirements of the organization. For Example: after reading a feature, the user can select “Nice to Have”, if this feature is not very critical for maintenance, but this feature would be nice to have, as long as this is a standard feature of the CMMS and does not have to be customized, just for the company.
Create Specifications

For creating detail specifications needed to select and implement the right CMMS, it is important to review all the features in the SELECTCMMS application. First, review all the needed features and functions in all the required modules (Main Modules and Optional Modules) and make the appropriate selection for each of the features and functions (Must Have, Important, Nice to Have, Not Important). After completing the above process, click on “Create Specifications” on the Main Menu bar. A specifications document in "Microsoft Word" is automatically created (Please refer the screen below).

![Figure 13: Specifications for CMMS Selection Screen for SELECTCMMS](image)

Figure 13: Specifications for CMMS Selection Screen for SELECTCMMS
WORK REQUEST MODULE

MUST HAVE

Create work request using any computer terminal within the organization using company Intranet

Able to specify when the equipment will be available (date or time) for maintenance purposes

Ability for the approver to further request information from the requester (with the CMMS system)

Able to electronically submit the work request to appropriate department or person in the organization

Multiple approvals can be setup where routing can be automated (more than one person approval needed)

IMPORTANT

Create work request using any computer terminal from anywhere using the Internet web browser

Reasons for the equipment failure can be entered or selected from a drop down list in the work request

Figure 14: Specifications (Work Request Module) for SELECTCMMS

This detailed specifications document in Microsoft Word is created, based on the features and functions selected. This detailed specifications document can be utilized to solicit proposals from different vendors to evaluate, select and implement the right CMMS to enhance the reliability of equipments, increase productivity of maintenance department and generate higher profits for the organization.
CMMS MAIN MODULES

Many different modules are currently available in the CMMS systems. Each module has many different features and functions that will determine how efficiently, CMMS can be utilized for cost-effective maintenance. These features and functions in each of these modules need to be carefully evaluated based on the maintenance and operational requirements of the company. After carefully reviewing and evaluating different features in every module, all features needed for cost efficient maintenance should be selected. Some of these questions should be answered before evaluating and selecting different features and functions needed in each CMMS modules.

- What types of equipments and/or assets need maintenance?
- What kind of experience and skills do maintenance employees have?
- How are the work requests created, routed and approved?
- How are the work orders created, assigned and updated?
- How are schedules of employees generated and balanced?
- How are priorities of maintenance decided and by whom?
- How are preventive maintenance tasks decided and setup?
- How often is preventive maintenance program reviewed and updated?
- How is maintenance work performed and how is the information updated?
- How are the inventory spare parts managed and kept updated?
- What kinds of reports and charts does the management need?
- What types of maintenance histories are maintained and reported?
- What kind of analysis is performed for the equipment reliability?
Work Request Module

For any corrective maintenance to be performed on equipments, a work request is commonly utilized to inform the maintenance department of any equipment problems and also the priority needed to address the problem. In many companies, individuals outside the maintenance department (Example: Production and Operations personnel) are usually authorized to prepare and submit the work requests. Depending on the size of the company, someone in each department may be authorized to create and submit work requests to the maintenance department.

Equipment Needs Maintenance Work 

This information needs to be communicated quickly and clearly to the maintenance department. 

(There should be no questions/confusion about Maintenance work that needs to be performed)

When submitting a work request to the maintenance department, the CMMS should have the provision to provide detail information of the problem, which will inform the maintenance department the importance of the maintenance work needed and the urgency needed to complete the work. By providing detail information in the work request, the person in charge of approving the work request can approve or reject it without having to further investigate the problem. A work request simply requesting, for example, "pneumatic leak tester not working properly" and without any further information or attached drawings, requires a substantial amount of investigative time determining the scope of the maintenance problem, the urgency associated with the problem and which maintenance technician (for example: mechanical, electrical etc.) should be directed to address the problem. A more specific description of the particular maintenance problem such as, "pneumatic leak tester not working properly, as air is leaking at the pipe joint near the third solenoid valve" eliminates the need for a
supervisor or maintenance technician to investigate the problem prior to approving the work request. In many instances, attaching a drawing or picture of the problem area can significantly help maintenance to identify the problem and address it quickly. Thus a clear, understandable, and specific description of the problem on the work request along with needed drawings or pictures can avoid unnecessary delay and expedite the maintenance process. Therefore, it is important to understand, that the work request format plays a very important role in the overall scheme of operations and maintenance management.

![Diagram of Different Methods of Reporting Maintenance Problems]

**Figure 15: Different Methods of Reporting Maintenance Problems**

When selecting a CMMS, considerable attention must be devoted to assure that the software features and functions can support the desired work planning and scheduling process. The maintenance process and the software features must be compatible to perform the maintenance function smoothly and effectively. It is also important that the CMMS selected is user friendly and helpful to all the concerned people – maintenance planner and scheduler, maintenance manager, maintenance supervisor, maintenance
engineer, maintenance technician, production employees and all others who will use or interact with the CMMS system.

There are many different formats and methods to create and submit work request to the maintenance department (one example shown below). The company selecting the CMMS should clearly understand their maintenance requirements (for example: size of company, types and complexity of equipments, maintenance employees experience, etc.) and depending on the maintenance procedures, type of industry, amount of information needed on the work request, files or drawing attachments needed, etc., select the best format and method to use in order to create and submit a work request to the maintenance department.

Figure 16: Example of Work Request Module Screen (Source: MaintScape)

There are many different features and functions in the work request module, which are used to create and submit a work request to the maintenance department.
Depending on the nature of company's business, its maintenance practices and procedures, these features (shown below) should be carefully evaluated and selected to improve maintenance efficiency and enhance the reliability of the equipments. It is important to note, that all these features (shown below) may not be available in any one individual CMMS system. These features should be carefully evaluated and then based on the company's maintenance process and procedures the right features should be selected to improve the reliability of equipments and enhance maintenance productivity.

- **Work request number** This is a number assigned to keep track of the work request. Many systems automatically assign a number or a user can type in the appropriate number.

- **Date requested** This is usually the date the work request was created. Many systems automatically assign the present date or a user can type in the appropriate date.

- **Date desired** This is the date when the work needs to be completed and can usually be selected from the dropdown menu.

- **Equipment name and/or number** This can usually be selected from the dropdown menu or a user can type in this information. It is helpful if the user can select this from a dropdown menu.

- **Equipment details** It would be extremely helpful and can save significant time and avoid any mistakes, by having the system fill in the appropriate boxes automatically, once the equipment name and/or number is selected from the dropdown menu. Other equipment details such as equipment name, make, model, vendors name, warranty information, building number, location details, equipment class etc. should be automatically displayed in the appropriate box in the work request.
Work request subject This is typically used to identify the problem at a glance. Users can usually select the appropriate subject from the dropdown menu or can type in the appropriate subject.

Detail description of the problem This is the most important part of any maintenance work request. This information is usually typed in by the user, which can provide detail description of the problem. This will help the maintenance department to correctly identify the problem and then develop a work order with the right personnel and materials, to quickly and correctly address the problem.

Reasons for equipment failure This is a very helpful feature and many systems do not have this feature. Based on the types of failures, a list of “reasons for equipment failures” can be created as a dropdown menu and then the appropriate reason can be selected. The user may also have the option of typing in the reasons for the equipment failure.

How was the problem or failure detected This is a very helpful feature and many systems do not have this feature. A dropdown menu can be created such as “routine inspection, machine breakdown, parts jammed, etc” and the appropriate item can be selected. The user may also have the option of typing in the appropriate information.

Attach Files and/or drawings This is a very helpful feature and not many systems have this feature. Additional files and/or drawings can be attached to the work request to provide the maintenance department with more useful information to correctly identify the problem which can help to save significant time and avoid unnecessary investigation of the problem.

Requested by This can be typed in or selected from the dropdown menu. Selecting from dropdown menu helps to avoid typing all the information.
- **Phone number, email address etc.** It would be extremely helpful and can save significant time and avoid any mistakes, by having the system fill in the appropriate boxes automatically, once a requester is selected from the dropdown menu. The person's phone number; mobile number, email address, pager number, title and designation, department, additional comments (any comments about this requester, for example: has some experience in operating and maintaining the tube-cutting machine) etc. should be automatically displayed in appropriate box in the work request.

- **When will equipment be available for maintenance** This will help to schedule the maintenance work based on the equipment being available.

- **Cost center** This is the information to which cost center maintenance work needs to be charged.

- **Priority** This can be selected from the dropdown list example: normal, emergency etc. or can be entered by the user.

- **New requester** This can help to add an entry for a new requestor to the contacts table and fill out all the details for this requester, like phone number, email address, etc. which can be used to automatically fill in the appropriate boxes.

- **Work category** When work orders are issued, they can be assigned a work category. Examples of work categories might be mechanical repairs, electrical repairs, shutdown, safety inspection, etc. Work categories should not be confused with trades. For example, more than one trade might be required on the maintenance job.

- **Work access code** For some maintenance jobs, permission to do the work can only be granted at a particular time of day, or when permission has been obtained from a particular person. CMMS can record this information in the form...
of access code (dropdown menu). An access code states any conditions that may apply to particular work requests.

These are the detail questions (features and functions shown below) that need to be evaluated for selecting the right “Work Request Module” in the CMMS system. These detail questions are listed in SELECTCMMS application under the “Work Request Module”. The company can select the right features and functions needed in their “Work Request Module” by reviewing these questions and selecting the appropriate response (Must Have, Important, Nice to Have, Not Important) based on their company’s requirements.

Create Work Request

➢ Create work request using any computer terminal within the organization using company Intranet
➢ Create work request using any computer terminal from anywhere using the Internet web browser
➢ Create work request using a form custom created by the company, for submitting work request
➢ Reasons for equipment failure can be entered or selected from a drop down list in work request
➢ Unlimited files, drawings, pictures and other details can be attached to the work request
➢ Unlimited links to websites of parts vendors and manufacturers can be attached to work request
➢ Many different formats of work request templates are available to create the work request
- Able to specify when the equipment will be available (date or time) for maintenance purposes

**Edit Work Request**

Sometimes, the person creating the work request may need to make changes after having submitted the work request to the maintenance department. The reasons to modify the work request may be many; for example, the requester has additional information regarding the problem or the problem has become an urgent issue that needs the attention from the maintenance department as soon as possible. Therefore, it may be important to have a provision in the CMMS that can handle these changes. These are the detail list of features and functions that need to be carefully evaluated.

- Able to make further modification to the work request after it has been submitted for approval
- Ability for the approver to further request information from the requester (with the CMMS system)
- Ability for the planner to further request information from the requester (with the CMMS system)

**Submit Work Request**

- Able to electronically submit the work request to appropriate department or person in the organization
- Notification can be sent automatically to the requester once the work request is accepted or rejected
- Able to submit emergency or urgent work request, which can receive immediate attention from maintenance
➤ Same work request can be sent to different departments, who can address the problem more quickly

**Approve Work Request**

➤ Multiple approvals can be setup where routing can be automated (more than one persons approval needed)

➤ Alternative approvals can be setup for routing and notification (any one person/department can approve)

➤ Electronic signature of the work request approval (or rejection) can be easily setup if needed

➤ Automatic email notification can be sent to the requester once the work request is approved or rejected

**Track Work Request**

➤ Able to easily check the status of the work request by the requester (with one or two easy steps)

➤ Able to easily check the status of the work request by the approver (with one or two easy steps)

➤ Able to easily check the status of the work request by the planner (with one or two easy steps)

➤ Able to easily check the status of work request by any authorized person (with one or two easy steps)

**Print Work Request**

➤ Able to print the work request by the requester once the work request is submitted for maintenance work
- Able to print the work request by the planner once the work request is approved for maintenance work
- Able to selectively print the work request (any part of the work request) by any authorized persons

**Close Work Request**

- Work request is automatically closed, once the approver approves it and a work order is created
- Work request is automatically closed, once the approver rejects it and no work order is created
- Work request can manually closed (or opened) by any authorized person in the organization

**Work Request - Other Details**

- Multiple work requests for the same type of maintenance work can be identified by the system
- History of the work requests can be generated based on requester, equipment, department, dates, etc.
- Urgent or emergency maintenance work requests can be automatically identified by the system
- Once work request is approved, the scheduled completion date is automatically notified to the requester
**Work Order Module**

Once the work request has been created and submitted to the maintenance department, it has to be reviewed by the maintenance manager or maintenance supervisor/engineer for approval. After the work request has been approved, the work request is usually converted into a formal work order that is utilized to perform the maintenance work on the equipment. A Work Order module is typically used to convert the work request into a formal work order.

The “Work Order Module” is the heart of any CMMS system, which provides the basis for efficient planning, scheduling, controlling and tracking of all maintenance work (both preventive and corrective maintenance) performed in the organization. The Work Order Module provides the tools required for effective maintenance management. It interacts with all other modules in the CMMS system, to efficiently manage, track and control all maintenance activities in the organization.

A work order should be used for all maintenance related work, whether it is an emergency (corrective) or planned (preventive) maintenance. This will help to correctly identify the work to be performed, provide start and end dates, assign appropriate maintenance personnel, assign components or parts to be used for maintenance, list any safety requirements (lockout/tagout procedure), store maintenance history (for future reference) and also generate detail documentation. The documentation should clearly identify the technician (or technicians) who performed the work, duration of the work, worker comments, repair methods used, components used for the work, cost and quantity of each component and finally acceptance of work performed by the person or team who requested this work.

These are some of the important questions that need to be answered, before selecting the appropriate features needed in the Work Order module.
o How are the work orders created and approved?
o How are the work orders scheduled and prioritized?
o What kinds of work instructions provided with work order?
o How are personnel and materials assigned to work orders?
o Are any outside contractors assigned to the work orders?
o How is the workload balanced among all employees?
o How are employees notified about their work schedule?
o How does employees update work order after performing the work?
o What kind of information is entered to update the work order?
o Is estimated cost and actual cost to perform the work compared?
o What kind of work order histories are stored and maintained?
o What kind of work order reports are needed by the management?

Different work order formats should be available to schedule various maintenance activities. (Example: Equipment maintenance, Facilities maintenance, Vehicle maintenance, etc.). Detailed work instructions can be attached to the work order in various formats. (Example: Word document, CAD drawing, Excel file). In order to save time and avoid any mistakes, the Work Order module should automatically create a work order using all the information provided in the work request. Many work orders need more then one technician to be assigned to complete the work. The planner responsible to assign technicians to the work orders should be able to choose the appropriate technician from the drop down list. This drop down list should be able to filter and display only the technicians based on their specialty (for example: PLC programmer, Welder, Fitter, etc.) In order to efficiently manage the maintenance budget, it should be able to correctly distinguish between Preventive maintenance and Corrective maintenance work orders. By keeping the preventive and corrective maintenance work orders separate, it will be able to identify where resources (personnel and materials) are being used and
can be tracked effectively. Once a work order is completed, it should be stored in the history folder to be used to create user-defined reports and perform analysis to enhance equipment reliability. It is extremely important that the Work Order module have the ability to store and maintain a historical data of critical maintenance related information that enables the users to manage maintenance process as a business activity to increase the profitability of the company.

Many different features and functions are available in the work order module, which are used to generate a work order from a submitted work request. Depending on the nature of company's business, its maintenance practices and procedures, these features should be carefully evaluated and then selected to improve maintenance efficiency and enhance the reliability of the equipments.

Figure 17: Example of Work Order Module (Source: SmartMaintenance)
These are some guidelines or information that should be carefully evaluated for selecting the CMMS work order module. It is important to note that, all these features may not be available in any one individual CMMS system.

- **Work order number** This should automatically be assigned or can be typed in by the user
- **Work request number** This is the information from the work request
- **Requested by** This is the name of the requester from the work request
- **Phone number, email address etc.** Once a requester is selected from the dropdown list, the persons phone number; mobile number, email address, pager number, title and designation, department, additional comments etc. should be automatically displayed in the appropriate box
- **Type of maintenance work** Example: corrective, preventive, predictive maintenance, etc.
- **Equipment number** This is usually the equipment number (asset number) from the work request.
- **Equipment details** Once a equipment number is chosen from the dropdown list, the equipment details such as equipment name, make, model, vendors name, warranty, building number, location details, equipment class etc. should be automatically displayed in appropriate box.
- **Equipment class** Example: mechanical, hydraulic, pneumatic etc. This is user defined and can be used to identify the correct class or code used in the company.
- **Department name** This is the name of the department, where the equipment is located.
- **Department number** The number assigned to a particular department.
- **Date created** The date and time this work order was created. This is very helpful for tracking and keeping the maintenance history.
- **Approval status** Example: approved, not approved, pending, etc. This helps to see that the work request has been approved or not. If approval is needed then this helps in setting up the approval process.
- **Work start date and time** It should be able to assign this information from drop down list. This will save time, instead of typing all this information.
- **Work end date and time** It should be able to assign this information from drop down list. This will save time, instead of typing all this information.
- **Work duration** Number of days and/or time needed to complete this particular Work Order.
- Work category When work orders are issued, they can be assigned a work category. Examples of work categories might be mechanical repairs, electrical repairs, shutdown, safety inspection, etc. Work categories should not be confused with trades. For example, more than one trade might be required on maintenance job.

- Work order subject This is from work request or from the dropdown list.

- Detail description of the problem This is from the work request. Also add any additional information that will be helpful to the technicians.

- Reasons for equipment failure This information from the work request.

- Files and pictures Attach files, pictures, and any other information that can be helpful to the maintenance technician performing the maintenance.

- Cost center The cost center maintenance needs to charge this work order.

- Priority This should be able to select from dropdown list example: normal, emergency etc. based on the information provided on the work request or the user can assign this information.

- Requested by This information from the work request. Have the requestors phone number, email address and other additional information.

- Work access code For some maintenance jobs, permission to do the work can only be granted at a particular time of day, or when permission has been obtained from a particular person. CMMS can record this information in the form of access codes (dropdown menu). An access code states any conditions that may apply to particular work orders.

- Labor assigned This is the information about who will be assigned to complete this work order. Can be more than one person.

- Estimated time needed by in-house workers This is the estimated time [days or hours] needed to complete this work by in-house workers—once the work is
completed then the actual time is added to the work order, which will be helpful to compare them. If there are more than one trades person assigned to the work order (example: mechanical, electrical, plumber etc.), then each of them should be individually assigned an estimated time to complete the work

- **Estimated time needed by contract workers** Add an estimate of labor time from outside workers. For example, if a particular job requires an outside plumber to help in-house workers, then the time of the plumber can be added to the work order

- **Hourly cost of each in-house worker** Every in-house worker selected to do the work, should be assigned cost per hour to do the work, which can be automatically selected to calculate total cost of labor to do the work

- **Estimated cost for in-house workers** Based on the number of hours assigned to the in-house workers, the total cost of in-house labor should be automatically calculated for this work order

- **Actual time for in-house workers** This is the actual time for in-house workers to complete the work

- **Actual cost for in-house workers** This is the actual cost for in-house workers to complete the work

- **Actual cost for contract workers** This is the actual cost for contract workers to complete the work

- **Materials assigned** Assign all the materials/components from the inventory that are going to be needed to complete this work. Once the materials/components are assigned to the work order, these materials should be selected and assigned to this work order from the inventory, so that these materials should be available when the in-house worker assigned to work order goes to pick them up from the
inventory. This would guarantee that the assigned materials would be available when the work is to be performed and avoid any unnecessary delays.

- New purchase order If some or all of the materials for this work order are to be supplied by an outside contractor, a purchase order needs to be created and sent to the contractor describing the required materials.

These are the detail questions (features and functions) that need to be evaluated for selecting the right "Work Order Module" in the CMMS system. These detail questions are listed in SELECTCMMS application under the "Work Order Module". The company can select the right features and functions needed in their "Work Order Module" by reviewing these questions and selecting the appropriate response (Must Have, Important, Nice to Have, Not Important) based on their company’s requirements.

Create Work Order

- Able to automatically create work order based on information provided in the work request
- Able to create work order by selecting valid data from the drop down boxes
- Detail instructions can be provided in the work order, helpful to the maintenance craftsman
- Attach unlimited drawings, files, pictures and other details to the work order
- Able to correctly define the shift hours, day and time in the work order
- Able to add lockout/tagout and other safety procedures in the work order
- Able to attach unlimited links to drawings, parts and vendors to the work order
- Able to develop customized work order template, to create different types of work order
- Able to assign user definable work order numbers to the work order
- Able to create new work order templates for different types of work orders
Able to customize or modify existing work order templates based on company's requirements

Able to provide extensive filtering (for the dropdown boxes) in the work order module

Able to identify the actual cause of the equipment failure (from work request or drop down list)

Able to modify the work order after it has been submitted for approval (by authorized persons)

Able to prevent modification to the work order by unauthorized persons

Able to clearly identify the contract maintenance (or outside) on the work order

Able to combine both in-house maintenance and contract maintenance on one work order

Able to provide information on when equipment will be available for maintenance work

Able to provide links to the needed drawings to be retrieved directly from the work order screen

Able to edit the drawings from within the work order screen

Able to submit the work order to the appropriate person/department for approval

Five or more levels of work order hierarchy can be scheduled separately

Able to get electronic signatures on the work order and maintain an audit trail

Able to assign persons or parts not initially assigned to the work order

**Assign Personnel**

Able to match personnel skills to the tasks to be performed from the work order screen
➢ Able to add unlimited number of employees (craftsmen) needed to complete the work order
➢ Able to automatically update employee schedule once their name is added to work order
➢ Able to link employee time sheet hours and their detail schedule to the work order
➢ Able to automatically email, once the name of the employee is added to the work order
➢ Able to add maintenance employees pictures to the work order
➢ Able to see employee schedule and balance workload using graphical interface from work order screen

**Reserve Materials**

➢ All needed materials and spare parts can be listed and reserved for the work order
➢ Able to flag certain spare parts as 'critical spare parts' in the work order
➢ Able to flag certain parts or materials as 'hazardous material' in the work order
➢ Able to see parts status from the work order screen before/after reserving the parts for the work order
➢ Able to select new, used or reconditioned parts from within the work order screen
➢ Able to view the stock levels of each part from within the work order screen
➢ Able to select parts from multiple warehouses from within the work order screen
➢ Able to receive parts back into the stores/warehouses for any part that needs to be repaired
➢ Able to receive unused parts back to the stores/warehouses and stock levels can be adjusted
➢ Able to specify any part that is not available in stores and that needs to be ordered

Estimate/Actual Cost

➢ Total estimated dollar value of the work order is clearly identified on the work order
➢ Total estimated dollar value of the work order are used in establishing approval levels
➢ Able to correctly charge the cost of the work order to the appropriate cost center
➢ Able to prohibit the user to charge the cost of this work order to other's cost center
➢ Able to automatically assign inventory costs of the materials used for this work order
➢ Able to automatically assign labor costs based on the labor hours for this work order
➢ Able to automatically calculate the total cost of work order based on labor, parts and all other details
➢ Able to update the work order to reflect the actual cost of the work order after maintenance work
➢ Able to keep the estimated cost and actual cost of work order for comparison

Track Work Order

➢ Able to track work orders by dates, weeks, months, years, etc.
➢ Able to track work orders by plant, area, department, equipment, etc.
➢ Able to track work orders by individual maintenance employees
➢ Able to track work orders by individual contract employees
- Able to track start and end time for every employee working on work order
- Able to track work orders by type as safety, inspection, PM, etc.
- Able to track work orders that are being completed on time, being late, etc.
- Able to track work orders by billable work or non-billable work
- Able to track work orders being complete, active, yet to start, etc.

**Print & Close Work Order**

- Able to update the work order (by authorized persons) after maintenance work is completed
- Able to open the work order after it has been closed (to modify any information)
- Able to charge labor (or any cost) to a closed work order (further work may have been performed)

**Work Order - Other Details**

- Able to create bar codes for all the work orders created (easy to retrieve the information)
- Able to identify and track equipments that are required to be off-line prior to maintenance work
- Able to identify hazards which need to be removed prior work being performed
- User can access information referencing the last work performed on the equipment
- User can access information referencing all the work performed on the equipment
Equipment Module

The Equipment module, also called as Plant/Asset register, contains details of all equipments (and other assets) that need to be maintained. The equipment module typically contains information such as equipment make, model, model number, serial number, building number, location, equipment details, date purchased, warranty information, contract information, original cost, cost center, depreciation rate, depreciation method, etc.

![Figure 19: Example of Equipment Module Screen (Source: Chase CMMS)](image)

The following types of information should be available in the equipment module of the CMMS system, to efficiently maintain, track and control maintenance to improve the reliability and maintainability of equipments and reduce the overall maintenance cost. A good CMMS system should also have the capability to customize the information usually required by an individual company.
- **Equipment Name** The name of the equipment. This can be the name used within the company.

- **Equipment ID** An identification code for each piece of equipment. For example, equipment number may be used to identify this piece of equipment.

- **Make & Model** Basic identification information of the equipment.

- **Manufacturer** The manufacturer of this piece of equipment.

- **Vendor** The vendor who supplied this piece of equipment.

- **Picture** The picture of the equipment. It is helpful to have a picture of the equipment to easily identify and locate, especially in a large organization.

- **Building** The building where the equipment is located. The company may have many different buildings, so it is important to clearly identify the building where the equipment is located.

- **Location** The location of the equipment within the building. The exact location of the equipment is needed to help technicians to locate the equipment quickly.

- **Department** The department where this equipment is located or belongs.

- **Equipment Type** The equipment types table makes it possible to group pieces of equipment into classes. For example, it would be helpful to create classes like pumps, motors, milling machines, cutting machines etc.

- **System** The system to which the equipment belongs. A system is a set of separate pieces of equipment that make up a single entity. For example, a production line usually consists of many pieces of equipment, but for some maintenance purposes, it is viewed as a single system. If there is a breakdown in one piece of equipment on the production line, the whole line may have to stop.

- **Drawing** An identifier that specifies where maintenance personnel (and others), can find a schematic drawing of the equipment.
- **Contact** The person that maintenance personnel (and others) can contact, for any questions regarding the equipment.

- **Specifications** The specifications to be filled describing the equipment, which helps to attach on-line documents and/or diagrams to the equipment record.

- **Comments** A blank area where special comments can be entered about the equipment. For example, unique characteristics about this particular equipment can be entered here.

- **Warranty** The date when the original warranty on this equipment expires. For example, when a work request is created for this equipment, the system should automatically identify if this equipment is still covered under warranty.

- **Service Contract** The information about the company that provides a service contract on this equipment (if any).

- **Service contract list** This should list out any service contracts covering the equipment. For example, when a work request is created for this equipment, this list should automatically identify if a current service contract is available for this equipment.

- **Access Code** An access code for this equipment that can be placed initially on all work orders pertaining to this equipment. For example, this equipment may have access to maintenance, only during the off shift as equipment is too important to take down during normal work hours.

- **Cost Center** The cost center associated with this equipment. Maintenance expenses for this equipment can be billed to this cost center

- **Spare Part number** The spare part numbers used for this machine. This should list all the spare part numbers used for this machine

- **Vendors** This specifies the vendors who supply the spare parts for this equipment
- **Purchase Date** The date on which the equipment was purchased.

- **Original Cost** The original cost of the equipment. This should include all the costs pertaining to the equipment.

- **Depreciation Cost** The depreciation cost of the equipment per year or for a particular period of time assigned by the user.

- **Depreciation Method** The depreciation method that is used to calculate the depreciation cost per year.

- **Future Value** The estimate for replacement costs and scrap value on a given date for this equipment.

- **Replacement Cost** The cost to replace this piece of equipment with a similar make and model, if the equipment were to break down on the date given.

- **Typical Life** The estimated length of time that this equipment is expected to last.

- **Scrap Date** An estimate of the date on which this equipment will be out of service.

- **Scrap Value** An estimate of the amount of money this equipment can be sold for, once it has been taken out of service.

- **Obsolete** An obsolete code should be assigned to this equipment, once it will be taken out of service.

- **Ownership** This will specify an ownership for the equipment. For example, if this equipment has been leased from a company for a particular period of time.

- **Asset Account** This will specify an asset account for the equipment.

- **Meters** This will specify that the equipment contain one or more meters for preventive maintenance purposes.

These are the detail questions (features and functions) that need to be evaluated for selecting the right "Equipment Module" in the CMMS system. These detail questions are listed in SELECTCMMS application under the "Equipment Module". The company can
select the right features and functions needed in their “Equipment Module” by reviewing these questions and selecting the appropriate response (Must Have, Important, Nice to Have, Not Important) based on their company’s requirements.

**General Equipment Information**

- Detail information can be entered for every piece of equipment that needs maintenance
- Detail description of the equipment can be entered (will be helpful to maintenance employees)
- Equipments can be clearly identified, whether it is leased, owned, etc.
- If the equipment is leased, the details of the lease is clearly identified
- Photos/Pictures of the equipment can be attached in the equipment module for easier identification
- Name of a contact person (familiar with equipment) for each equipment can be clearly identified
- Additional space is provided to enter any other important information regarding this equipment
- Extensive user defined fields (for additional information) are permitted for end user customization
- Equipment module has the ability to accept details for facility maintenance
- Equipment module has the ability to accept details for vehicle maintenance
- Equipment module has the ability to accept details for any other type of maintenance (user defined)
- Keeps track of the exact location and the availability (day and time) for all the equipments
Ability to attach other files from any other application (can execute using original application software)

Equipment records can be easily copied to create other records (will save time during implementation)

Equipment records can be deactivated from work order generation (obsolete or unused equipments)

Equipment tree view is provided (which is a simple way to manage, analyze and maintain equipments)

A minimum of 3-tier hierarchy of location and priority assignments to each asset can be assigned

Unlimited Parent/Child Hierarchical Relationship Development for Equipment and Locations is provided

Able to import the data from a previous CMMS database system (or from any other source)

Plant Browser function (Windows Explorer style of navigation) is provided for ease of navigation

Equipments drawings can be attached (or linked) for each equipment/asset

Vendor drawings and other details for each spare part can be attached

Web links for the spare parts (any other components and/or vendors site) can be attached

Any attached files/drawings can be opened/executed from the system using original application

**Warranty/Service Information**

Warranty information is clearly defined and identified for every equipment/asset (all details provided)
Warranty start date and end date are clearly identified for every equipment/asset (all details provided)

Company that provides a service contract for a equipment is clearly identified (all details provided)

When work order is created, the system automatically checks to verify if the equipment is under warranty

When work order is created, system automatically checks to verify if equipment has any service contract

Value/Cost Of The Equipment

➢ Detail cost information for each equipment/asset can be entered (can be updated as needed)

➢ Keeps track of equipment/asset cost (or age) by the hour, day, week, month, year, etc.

➢ Keeps track of all purchased, leased and rental equipment based on cost, depreciation, etc.

➢ Every equipment/asset can be treated as its own profit and loss center

➢ Cost per hour (day, week, etc.) of owning and operating each piece of equipment can be tracked

➢ Cost breakdowns are provided - by ownership, major repair, running costs, depreciation, etc.

➢ Multiple rental rates may be established for each piece of equipment/asset (if needed)

➢ Equipment cost details is provided showing all charges booked against each equipment
Monthly (or user defined) depreciation report/graph can be generated showing all details.

Detail cost of equipment maintenance can be generated in a graphical form (or other format).

**Spares & Vendors Information**

- Provides a comprehensive, structured description of the spare parts used on each piece of equipment and also identifies all the sub-components.
- All spare parts needed for equipment are clearly identified by name, number, cost, quantity, etc.
- Spare part information is directly linked to the inventory to verify the availability of these spares.
- Detail vendor information is provided or linked, for each spare part (website links can be useful).
- Details for more than one vendor can be entered for each spare part (will be useful for cost control, etc.).
- Spare parts are clearly identified by units, sub-units, etc. for easy selection and reference.
- Critical parts for the equipment can be easily identified and linked to inventory for better control.
- Detail description of critical spare parts (or any important ones) for the equipment can be provided.

**Equipment meters (for PM)**

- Can setup unlimited number of meters (for PM) which will automatically create work orders based on these meter settings.
Meters can be setup based on different properties like, hrs, miles, etc.
Meters can be setup, which will consider weekends, holidays, etc.
Able to quickly edit and update meter settings for any equipment for PM
Easy to copy the meter settings created for one equipment to multiple equipments
Track and view all the PM’s assigned to the equipment by unit, subassembly, main assembly, etc.
Track and view all the PM’s assigned to the equipment by hours, days, weeks, months, etc.

**Track Downtime for Equipments**

- Can track and create graphs/charts for downtime on each and every piece of equipment
- Can track and graph downtime based on user defined variables (like time, cost, production loss, etc.)
- Can track and create graphs/charts for downtime based on MTBF, MTTR, etc.
- Detail downtime/equipment failure and uptime/availability statistical information is available
- Mean-time-between-failure and mean-time-to-repair statistical information is available
- Equipment performance analysis and maintenance strategy planning is made available

**Equipment module – Other Details**

- Maintenance history for all equipments can easily be tracked and accessed (by date, by work order, etc.)
- History of equipment downtime, time to repair, etc. can easily be tracked and accessed
- History of all parts used for each equipment (days, work orders, etc.) can easily be tracked and accessed
- Data entry can be automated and/or updated using barcode, PDA’s etc.
- Data entry can be automated and/or updated using other application software (by integration)
- Bill of materials can be displayed (and printed) for all equipments (by unit, subassembly, etc.)
- Material cost and labor cost history can be displayed (and printed) in graphical format
- Equipments drawings and other documents can be attached (or linked) for each equipment
- Vendor drawings, web links and other details for each spare part on equipments can be attached
- Any attached files/drawings/documents can be opened/executed/modified from original application software
Personnel Module

The Personnel module, also called as Labor module, contains details of all maintenance personnel (and the contractors) that are used to maintain the equipments. Effective and meaningful personnel management goes far beyond tracking an employee's name, address, social security number, phone number, date of birth, etc. Today's complex labor issues require companies to have complete information on all employees (and all contractors) working for their company. It is important that this information can be readily available and can be easily used to set up personnel schedules, work orders, purchase orders and all other details.

Therefore, in the over all scheme of maintenance, personnel module also plays a very important role to ensure that the appropriate personnel is assigned to perform the correct job.

To ensure higher employee productivity and to sustain (and improve) optimal equipment performance, maintenance (and production) employees must clearly understand the roles and responsibilities involved in their job. The “Personnel Module” helps companies to manage detail personnel information, which will link with other modules to improve equipment utilization, enhance employee productivity and generate higher profits. Typically “Personnel Module” allows companies to track and manage complete employee details (name, social security number, address, etc.) charge rate, pay rate (regular and overtime), craft details (plumbing, welding, electrical, etc.) training and certification records, classes/seminars attended and many other details.
These are the detail questions (features and functions) that need to be evaluated for selecting the right "Personnel Module" in the CMMS system. These detail questions are listed in SELECTCMMS application under the "Personnel Module". The company can select the right features and functions needed in their "Personnel Module" by reviewing these questions and selecting the appropriate response (Must Have, Important, Nice to Have, Not Important) based on their company’s requirements.

**General Personnel Information**

- Detail information can be entered for every maintenance employee (EX: name, ID number, title, etc.)
- Detail information can be entered for every contract employee (EX: name, ID number, title, etc.)
- Detail information can be entered for non-maintenance employees (Ex: name, ID number, title, etc.)
- Detail description or comments can be entered for every employee (Ex: good with pneumatic circuits, etc.)
- Employees detail roles and responsibilities, documents they can approve, etc. can be easily entered and retrieved
- Personnel templates (user defined) can be created and copied, to help reduce time in creating employee records
- Photos/Pictures of the employee can be attached in the Personnel module for easier identification
- Other applications can be linked, which can be opened from the personnel module (Ex: Microsoft Word, etc.)
- Multiple wage codes for employees who perform several types of jobs or who work several shifts can be easily entered
- Each employee can be assigned access security levels for each of the functional areas of the system
- Employees can be related hierarchically – Ex: Technician to Supervisor to Manager, etc. (who they report to)
- Any updates made to employee during their employment (Ex: pay rate, position, etc.) can be stored and retrieved
- Personnel details can be easily retrieved based on the employee's name, ID number, department, etc.
- Users can be assigned by how they interact with the System: Ex: Access rights to Read, Edit, Delete, etc.
- Every employee is assigned a password which will help to access the system based on security level
- Personnel information can be stored and retrieved based on - by employee, contractor, etc.
- Labor records can be associated with craft/skills records, for organizing labor by craft/skills
- Employees can be assigned multiple roles – Ex: electrician, parts buyer, etc. (helpful for quick retrieval)
- Quality control reports, productivity (work performed by employees), etc. can be easily maintained and retrieved
- Uniforms, personal protective equipment, tools, etc. issued to the employees can be easily tracked

**Skills and Training**

- Unlimited skills and qualifications can be clearly defined/edited and easily be retrieved for reference
- Labor charges (dollar amount range) can be assigned to different skills and qualifications
- Skill sets (Ex: PLC Programming, Welding, etc.) can be assigned to all employees (to match PM tasks vs. Skills)
- Skill sets assigned to employees can easily be edited as needed (Ex: due to more training, promotion, etc.)
- Training requirements, completed training, certifications to comply with ISO 9000, OSHA, etc. can be entered
- All certification and training requirements can be defined and tracked based on Trade, Skills, etc.
- All certification and training history (training date, training details, etc.) can be maintained and tracked
- Database of qualified training providers, based on trade and skills can be maintained and retrieved
- Personnel skills can be matched with the Preventive Maintenance tasks, for efficient assignment
- Employees (and managers) can be notified (user defined frequency) of any renewal of certification
- Employees requiring renewal of certification/training can be notified by email, viewed on-line, etc.

**Personnel Time Management**

- Employees can enter the start time and end time (available time) for the entire week, and/or month
- Employees can enter (block off) the vacation time (unavailable time) or any time off from work
- Multiple time reporting methods including, individual entry, time clock entry, etc. can be used for tracking time
- Regular time, over time, double time, etc. can be tracked and integrated with Accounting/Financial application
- Personnel records history for each employee can be maintained Ex: attendance, vacation, sick time, over time, etc.
- Number of vacation days used/remaining for employees can automatically be updated and tracked
- Personnel module can allow users to track actual time worked on specific work order tasks
- Actual labor hours spent on work orders can be organized and reported in a timecard format.
- Actual hours worked on tasks can be tracked and compared to established estimated times
- Time sheet reports for Management (and others) can easily be generated and emailed or viewed On-Line
- Timesheets (hours available for work) can be updated by employees, which can be used for scheduling
- User defined approval routing for timesheet (regular time, over time, etc.) can be generated
- Any approved overtime that was accepted by an employee can be correctly tracked and displayed
- Any approved overtime that was declined by an employee can be correctly tracked and displayed
- Detail timesheet (actual hours worked) for each employee, department, etc. can be generated by date, week, month, etc.

**Labor/Personnel Cost**

- Different labor rates for regular time, over time, double time, etc. can be assigned to all maintenance employees
- Different labor rates for regular time, over time, double time, etc. can be assigned to all contract employees
- Different labor rates for regular time, over time, double time, etc. can be assigned to all temporary employees
- Regular labor rate can be assigned and labor rate for over time, double time, etc. is automatically calculated
- Billing labor rates can be specified at the department level, employee level or trade/skill level
Current labor rate, new labor rate, effective date of new labor rate, etc. can be assigned

Percentage overhead cost can be assigned to every employee (assigned overhead cost can be user defined)

Labor cost history for every employee can be tracked and displayed (labor cost/hr, total labor cost/month, etc.)

Labor cost assigned to employees/contractors is used to automatically calculate total labor cost for work order

Both internal and contract labor used in a work order and total labor cost can be calculated appropriately

**Scheduling Details**

Employee schedules can be generated, balanced and displayed using Graphical Scheduling System

Employee schedules can be generated, balanced and displayed using Gantt Charting Features

Detail workload (work orders, hours assigned, etc.) can be displayed for each employee/contractor

Unassigned employee hours can be clearly displayed to allow for effective and balanced scheduling

Conflict in employee schedule can be clearly displayed to allow for effective and balanced scheduling

Assigned hours, unassigned hours, conflict hours, etc. can be displayed in different colors in a Gantt chart

Drag and drop work hours from one craftsman or contractor to another craftsman or contractor
Drag and drop unassigned hours from a work order to any craftsman or contractor (based on availability)

Split hours on any drag and drop operation (Ex: 2 hours from one craftsman to 1 hour each for 2 other craftsmen)

**Personnel History**

Detail Employment history (user defined) for every employee can be generated and displayed

Detail Accident history (user defined) for every employee can be generated and displayed

Skills and Training history (user defined) for every employee can be generated and displayed

Detail Payrate and Position history (user defined) for every employee can be generated and displayed

Employee Work Order history (user defined) for every employee can be generated and displayed

**Other Personnel Details**

Work order can be generated by selecting and clicking employee’s name in the Personnel Module

Able to assign OSHA illness type codes, OSHA accident / body part reporting codes

Able to Create, Store, Access and View the Audit Trail for all Personnel details

Able to establish email approval chains for work request/purchase request (people who can approve)
- Able to assign and track purchase order and work order approval limits based on dollar values
- Able to assign (and able to edit) Manager, Supervisor, Department, Division, etc. to every employee
- Able to create and manage individual website for personnel details (access to authorized personnel)

**Preventive Maintenance Module**

Preventive maintenance (PM) is a schedule of planned maintenance actions (tasks and procedures) in order to prevent breakdowns and failures of equipments (or any assets). The most important goal of preventive maintenance is to prevent the untimely failure of equipments. As Ben Franklin said: "An ounce of prevention is worth a pound of cure". It is far less expensive to perform routine preventive maintenance rather than corrective (breakdown) maintenance due to untimely equipment failure.

PM is designed to preserve and enhance equipment reliability by repairing or replacing worn out components before they actually fail. Preventive maintenance (PM) activities include equipment checks, cleaning, adjustments, lubrication, oil changes, and partial or complete overhauls of components (and systems) at specified periods (based on time or utilization). In addition, workers (production and maintenance) can keep track of any equipment deterioration, so they can repair or replace worn out parts before they cause untimely equipment failure. Recent technological advances in tools for inspection and diagnosis have enabled even more accurate and effective equipment maintenance.

The ideal preventive maintenance program would prevent all equipment failures (zero breakdowns) before they occur. However, this is an extremely difficult goal to achieve and many organizations continuously strive to attain this goal.
Once a decision is made to perform preventive maintenance (PM) for a particular equipment or asset, these are some of the things that need to be considered to setup an effective preventive maintenance program.

- What work (detail tasks) needs to be performed for each PM schedule?
- How often do these PM tasks need to be scheduled?
- Which personnel need to be assigned to perform these tasks?
- What spare parts and tools are required to complete these tasks?
- What days and time need to be assigned to complete these tasks?
- Any lock out/tag out procedure need to be performed for this PM?
- How soon PM information needs to be communicated to personnel?
- What PM's should be combined (location, skill sets, equipments, etc,) together in order to improve the PM implementation workflow?
- What inspection/check list or task list document, CAD drawing or any other details should be printed with the PM Work Order.
- What determines the success (or failure) of this PM task?

Using the "Preventive Maintenance Module" in the CMMS system, PM tasks can either be created for individual pieces of equipment or for entire building systems. For example, fire extinguishers (each building typically have several of them) may require an individual maintenance schedule. But setting up every fire extinguisher with an annual or semi-annual inspection would be time consuming; instead a single PM schedule for the entire building can be created for all fire extinguishers.

A task schedule specifies when and/or how often a particular Preventive Maintenance (PM) task should be done. Schedules are usually setup based on the needs and availability of the equipment. Schedules can be set for specific dates (for example, on the 10th of every month) or they can be set in relative terms (for example, a particular PM task should always be scheduled 45 days after the previous time that task
was performed). Preventive maintenance on equipment may also be scheduled by meter reading, instead of by date. This meter reading can be setup on the machine to read automatically or can be manually recorded by the employees. For example, a particular piece of equipment might require maintenance every 500 hours of use, as measured by a meter on the equipment. Maintenance (or Production) personnel would then enter meter readings every day, and CMMS would generate a work order for preventive maintenance when the meter reading reaches 500 hours.

For the Maintenance Personnel, ideally a single screen should provide a list of pending PM's that are assigned to each of them. They can print their PM's, complete and close the PM work order, record metering results and update the PM task lists to reflect any other work that needs to be performed as a routine maintenance. They can also submit more work requests if their findings (while performing the PM tasks) result in the need for any additional maintenance work.

For the Maintenance Manager/Supervisor, it should provide a overall view of all the completed PM's, any pending PM's that need to be re-assigned, skipped or additional PM's added within the schedule. In general, "PM Module" should allow routine scheduled maintenance tasks to be linked to equipments, maintenance personnel, spare parts inventory and cost accounts. In general, the preventive maintenance module should be easy to set up all the needed preventive maintenance tasks needed for efficient maintenance. It should provide the Maintenance Manager/Supervisor with a record of all maintenance activities and detail cost information that is generally required to forecast budgets and labor requirements.
The following types of information should be available in the Preventive Maintenance Module of the CMMS system, to efficiently maintain, track and control maintenance to improve the reliability and maintainability of equipments and reduce the overall maintenance cost. A good CMMS system should also have the capability to customize the information usually required by an individual company.

- **Job ID** (PM ID or Task) An identification code assigned to each PM task.
- **Subject** Usually a one-line description of the PM task
- **Equipment ID** Equipment identification number for the PM task
- **Equipment Name** Equipment name or Asset name for the PM task
- **Building** The building where the equipment (or asset) is located
- **Location** The exact location of the equipment in the building
- **Description** This section is the most important part of the PM module, which describes the detail work (PM tasks) that should be done for this PM. Most organizations write up task descriptions as systematic instructions or as checklists of the operations that should be carried out. This should be a continuous process and task descriptions should be updated regularly as things change.
- **Work Duration** This is the time estimated to take to complete the task. This is usually based on previous experience performing similar tasks. This should be continuously monitored and updated as things change.
- **Work Category** When work orders are issued, they can be assigned a work category. Examples of work categories might be mechanical repairs, electrical repairs, shutdown, safety inspection, etc.
- **Access** An access restriction code. This may indicate to workers when the work can or cannot be done. For some maintenance jobs, permission may be needed from the production department to access the equipment at a certain time.
- **Priority** A priority code indicating how urgent the work needs to be completed. Some organizations may wish to use a priority system to expedite urgent repairs.
- **Cost Center** The cost center associated with this task, if any. A cost center could be a Department or a General Ledger Account Number.
- **Labor** This contains information about all the personnel assigned to the PM task
- **Material** This contains information about all the materials/spare parts to be used during the task
- **By Date** Select this if the maintenance will be scheduled by date.
- **By Meter** Select this if the maintenance will be scheduled by meter reading.
- **Schedule Basis**: The date or meter reading when this particular maintenance task was last performed. This serves as a basis date for scheduling the next preventive maintenance task.

- **Next schedule**: Displays the next date or meter reading when the task will be scheduled.

- **Schedule Interval**: When maintenance is being scheduled by meter reading, this is just a number. Maintenance will be scheduled when the meter reading reaches "Schedule Basis" plus the "Schedule Interval".

- **Work Start**: The "Schedule Basis" is set to the date or meter reading at the time the job starts. Therefore, the next scheduled time for the task will be "Work Start" of the current job plus "Schedule Interval".

- **Work End**: The "Schedule Basis" is set to the date or meter reading at the time the job ends. Therefore, the next scheduled time for the task will be "Work End" of the current job plus "Schedule Interval".

These are the detail questions (features and functions) that need to be evaluated for selecting the right “Preventive Maintenance Module” in the CMMS system. These detail questions are listed in SELECTCMMS application under the “Preventive Maintenance Module”. The company can select the right features and functions needed in their “Preventive Maintenance Module” by reviewing these questions and selecting the appropriate response (Must Have, Important, Nice to Have, Not Important) based on their company’s requirements.

**PM Tasks and Procedures**

- Detail PM tasks (library of PM tasks and procedures) are provided, which helps in setting up an efficient PM schedule saving significant time
PM tasks are grouped logically to provide fast access to these tasks when needed. (Examples may be PLC Tasks, Drive Train Tasks, Motor Tasks, etc.)

PM tasks (in the PM task library) can be customized and regrouped, if needed.

Additional PM tasks can be created and added to the existing library of PM tasks and procedures.

"PM Task Templates" with several individual PM tasks, can be created to setup PM schedule for many equipments which need similar PM tasks.

Online Library containing several thousands of PM tasks and procedures can be accessed to setup PM schedule for equipments.

PM Tasks at Online Library are grouped logically to provide fast access to these tasks when needed. (Examples may be PLC Tasks, Drive Train Tasks, etc.)

PM tasks can be easily imported from other databases and/or other applications.

**PM Schedule Types**

- PM schedule can be created based on fixed time and/or incremental time, etc.
- PM schedule can be created based on fixed meter and/or incremental meter, etc.
- PM schedule can be created based on Fixed, Increasing, Accumulating, or Fluctuating time or meter.
- PM schedule can be created based on by days, day of week, fixed date, or runtime totals (miles, hours, gallons, etc).
- PM schedule can be created based on start date and/or completion date.
- PM schedules can be created for individual pieces of equipment or entire building systems (Ex: all fire extinguishers in a building).
- PM schedules can be quickly setup for multiple equipments by copying PM tasks.
PM schedule can be setup for tasks like inspection, metering, etc. (for multiple equipments)

PM work orders can be generated individually, batched and/or automatically.

PM tasks for equipments and buildings can be copied to increase efficiency of the PM system.

Unlimited Meter Types are provided in the PM Module (miles, hours, gallons, etc.)

Meter values can be customized (hours, miles, gallons, etc.) based on the users requirements

Unlimited Meter Triggers for Each PM schedule is provided to generate many PM work orders

Complete Meter Reading History is provided for accurate tracking of PM schedule and utilization

Meter Reading Validation Formula Definition

Automatic update of the Meter values (for any assets) is made possible using Instrument Tracking

Multiple criteria for PM work order generation is provided (example: hours run, date, meter, etc.)

Seasonal PM work orders can be generated for planned shutdowns (or during anytime of the year)

PM work orders can be combined based on similar assets or PM tasks (resources can be shared)

Work orders are automatically created based on criteria (time or meter) on the PM schedule.

System should notify, so that PM cannot be scheduled during peak production or some other period

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- System should notify, so that PM cannot be scheduled during holidays or company shutdown
- Specify date ranges when in-season work should not be done, or when off-season work must be done.
- PM can be scheduled to override regular scheduling to handle special situations.

**Preventive Maintenance Details**

- Work order is automatically created when due date or meter reading for a PM schedule is reached. (When a piece of equipment reaches its due date or meter reading, a work order is automatically generated. Each PM work order describes the task to be done, parts needed, tools required, persons responsible for the work, priority, due date, etc.)
- Drag and drop method is available for PM task lists to be added (or deleted) to any equipment PM schedule. (Simply drag (moves or copies) a task to another equipment item and that task becomes part of the target equipment item's task list immediately. You may also move equipment to different work areas by dragging equipment items to different work areas. When the equipment is moved the task list associated with this equipment item moves with it.)
- Drag and drop PM interface is available to copy the entire equipment PM task lists from one equipment to another
- PM schedules have detailed instructions (tasks), pictures, drawings, responsible staff, required materials and all other needed information.
- Pictures, drawings and any other documents can be attached to the PM work order
- PM tasks associated with PM schedule can be printed, exported and/or emailed as Word document
PM task lists for PM schedule can be attached in HTML, Adobe, XML, Word, and/or many more formats

Assign Personnel and Materials

- PM tasks can be matched to the Personnel based on their qualifications, training and experience
- Other workers (Ex: any non-maintenance workers) can be scheduled to any PM work order
- PM's can be assigned to internal maintenance employees and/or outside contractors.
- Invoices from outside contractors can be applied back to the appropriate PM work orders
- Lock out/Tag out procedures can be clearly identified and scheduled in the PM work order
- Any Safety precautions needed to be taken can be clearly identified in the PM work order
- Materials assigned to a PM schedule is reserved and available to be picked up on or before due date
- Non-stocked items or materials can be attached or scheduled to the PM work order
- Any Critical spare parts used in the PM work order can be clearly identified
- Any hazardous material used in the PM work order can be clearly identified
- Appropriate MSDS sheets can be attached and made available for PM work order
- Part exception notes can automatically be created if a PM work order requires a part that is unavailable
➢ Event Notification System in the PM's are automatically generated and printed or emailed.

**Track and Analyze PM**

➢ When PM work order is generated the system checks and notifies if the equipment is under warranty
➢ When PM work order is generated, the system checks and notifies if the equipment has any maintenance contract
➢ PM schedules can be displayed and viewed days, weeks or months in advance (helps management)
➢ PM scheduler is provided to graphically schedule PM (helps to assign labor to reduce/eliminate overtime)
➢ Maintenance Manager can easily review all the completed PM work orders (on-time, late, past due, etc.)
➢ Maintenance Manager can review all pending PM work orders, assign, skip or add other tasks
➢ Maintenance Manager can review all completed PM work orders for labor hours, materials used, cost, etc.
➢ Late PM tasks (started, but not completed on schedule) can be clearly identified and highlighted.
➢ Past Due PM tasks (scheduled to start, but not yet started) can be clearly identified and highlighted.
➢ Performs reliability analysis on an equipment, part, subassembly, etc. based on cause of failure
➢ PM system can automatically assign tasks and intervals based on equipment reliability analysis data
Many important PM details can be analyzed like, average completion time, average cost, etc.

Preventive maintenance (PM) can be analyzed to locate areas in need of improvement or adjustment.

Able to quickly and easily generate a PM analysis with graphs and charts (helpful for management).

Provides many reports like Cost of PM Labor, Cost of Parts, etc. - by Equipment, department, building, etc.

Detail breakdown of costs (labor, parts, etc.) can be quickly generated to know exactly how much it costs for each PM.

Total costs for PM related activities could be calculated and displayed by day, week, month, year, etc.

For each PM work order, total estimated cost and total actual cost can be easily calculated and updated.

**PM - Other Details**

Numerous filters are available (for dropdown menu) helping to reduce time needed for selection.

Duplicate PM work orders can be easily detected to avoid generating multiple work orders.

PM schedule is automatically updated to reflect when an equipment is obsolete or taken out of service.

PM Work orders can be quickly generated (and updated) to take advantage of an unplanned downtime.

Maintenance staff can record completion of PM work along with labor hours, parts used, additional comments, etc.
Maintenance staff can quickly review the previous PM work done and make adjustments accordingly.

- System allows to skip a scheduled PM (and reasons can be entered for skipping a scheduled PM).
- PM task lists can be saved in several useful formats and/or emailed directly from the system.
- Provides the option to combine multiple assets or procedures on a single work order automatically.
- Provides the option to increase or decrease PM frequency based on mean-time-between-failure.
- Provides the option to conduct detail forecasting ability to foresee future PM requirements.
- Provides the option to conduct detail PM Performance analysis and PM History analysis.

**Inventory Module**

Efficient inventory management is one of the most daunting issues facing many maintenance managers. The number of pieces of equipment in any given facility, as well as the various spare parts, tools and other items (needed to maintain the equipments in reliable condition) creates a significant challenge.

Timely and accurate inventory information is extremely important to the management in order to formulate a good purchasing plan, to avoid over-stocked or under-stocked inventory. With the help of the Inventory Module, management can easily obtain reliable and accurate inventory information (real-time inventory information) for good decision-making. An Inventory module is used to plan, monitor and control all inventory items (usually stocked inventory items) needed for cost-effective maintenance.
Thus, inventory module can efficiently be used to reduce the overall inventory budget, by maintaining optimum level of parts needed to keep the equipments in reliable working condition.

The inventory module typically contains information such as part number, part name, part description, storage location, purchase price, minimum level (reorder point), maximum level, inventory levels (inventory on-hand, on-order, on-reserve), manufacturer, vendor details, purchase orders, requests for quotes, etc. The Inventory module is usually designed, so that materials and parts used to complete the work orders are automatically deducted from inventory levels to always reflect the actual inventory in the stock room. Inventory warning reports are automatically issued (or purchase request/orders automatically generated) when the inventory reaches the reorder point (minimum safety stock level), or when the shelf life of the inventory parts is about to expire (some inventory parts have expiry dates, for e.g. certain fluids). Some Inventory Module does allow authorized persons to issue a purchase order for more materials or parts directly from the work order screen.

Inventory management can provide a great incentive to cost efficiently manage the inventory and in addition provides a great tracking system that will greatly help in reducing the time to find the appropriate component or part quickly. Inventory management is a major factor that can have great impact on cost-effective maintenance management. These are some of the things that need to be considered before deciding the features and functionality needed in the Inventory module.

- An inventory system that provide for easy acquisition, receiving, storage, access and use of spare parts
- A quick and simple way to associate spare parts with all the equipments for which they are used
o Easy to track and obtain accurate (real time) inventory information e.g. inventory on hand, on order, on reserve, assigned to work orders, etc.

o Charts are useful for seeing an overall picture or for observing trends. A system that provides easy and flexible charting capabilities

o Reports are extremely important for management. An inventory system that provide a simple way to create user specific inventory reports

o An inventory system that has the feature to create purchase orders quickly and efficiently (e.g. drag and drop inventory requisitions)

o An inventory system capable of performing different Inventory analysis and develop charts, based on the company's requirements

o An inventory system that can be used to create efficient links to the equipment where they are going to be needed

These are some of the information that should be easily available in an inventory module when looking for any spare part or tool for maintenance work.

o Stockroom availability information - have I got this part on hand?

o Stock details – how many parts do I have on hand, on order, etc.?

o Quick vendor reference - where can I get it really fast?

o Quick look up for last delivered price - how much does it cost?

o Replacement information - can I substitute this part with another?

o Track parts – can the parts be located easily in the system?

o Duplicate parts – can the system identify similar parts?

o Where used – which equipments uses this part?

o Purchase orders - are these parts on order, received, etc.?

o Vendor details – where can these parts can be purchased?

o Lead time information – when are these parts going to be delivered?
The following types of information should be available in the Inventory Module of the CMMS system, to efficiently maintain, track and control maintenance to improve the reliability and maintainability of equipments and reduce the overall maintenance cost. A good CMMS system should also have the capability to customize the information usually required by an individual company.

- **Part Number** A part number to identify the part (usually assigned by manufacturer or vendor or user-defined)
- **Part Name** A part name to identify the part (usually assigned by manufacturer or vendor or user-defined)
- **Part Description** A brief (or detailed) description of the part (additional information provided for better understanding of the part)
- **Last Cost** The last cost of this item. This information is helpful to compare the present cost with the last cost for this item.

- **Present Cost** The present quoted price for the part. This can be compared with the last cost or the standard cost.

- **Average Cost** The average cost of this item (based on the last few purchase orders or can be user-specific).

- **Building** The building that contains the storeroom (where part is stored).

- **Storeroom:** An identification code for the storeroom (this is user defined).

- **Storeroom Description** The name of the storeroom or some other identifying description.

- **Part Location** The primary location where this part is stored (Bin, shelf or storage box, etc.).

- **Manufacturer** The manufacturer for the part (It is important to have detail information about the manufacturer. E.g. link to website, phone number, email address, etc.).

- **Vendor Details** The preferred primary vendor for this part. It should contain address, link to website, contact person, phone number, fax number, email address, cell phone, pager, etc. (It is always beneficial to have more than one vendor assigned to each part).

- **Account** The cost center (or account) this part needs to be charged when creating a purchase order, when part reaches the re-order level.

- **Minimum Qty.** The minimum quantity to keep at this location. If the quantity on hand is less than the minimum specified at this location, a warning report should be issued or a purchase request/order generated to replenish part.

- **Equipment Used** Different types of equipments (equipment name, number, etc.) the part or item is used on.
- **Units of Measure** How this part is measured (e.g. by weight, length, etc.)

- **Drawing File** The name of the graphics file attached to this part. Usually it can be a CAD Module, DWG, DXF, PLT or some other file formats

- **On-Hand** The quantity of an item that is currently on-hand, i.e. the total quantity that is expected to be present in all the storerooms.

- **On-Order** When a purchase order is created, the total quantity of items on the purchase order are said to be on-order

- **On-Reserve** When a work order is created, inventory items can be reserved for this work order. These items are said to be on reserve

- **Stock Available** The total quantity of an item available in all the stock rooms. This is usually calculated as

  \[
  \text{Stock Available} = \text{On Hand} + \text{On Order} - \text{On Reserve}
  \]

These are the detail questions (features and functions) that need to be evaluated for selecting the right “Inventory Module” in the CMMS system. These detail questions are listed in SELECTCMMS application under the “Inventory Module”. The company can select the right features and functions needed in their “Inventory Module” by reviewing these questions and selecting the appropriate response (Must Have, Important, Nice to Have, Not Important) based on their company’s requirements.

**Part Location**

- Unlimited User Defined Company/Building/Sites can be assigned
- Unlimited User Defined Storeroom Locations can be assigned
- Unlimited User Defined Bin Addresses and locations for all inventoried Parts can be assigned
- Multiple storeroom feature available for users to track inventory in multiple storerooms
Parts can easily be moved between different store rooms and tracked accurately

**Part Details**

- Detail information can be entered for every piece of inventory part (Ex: part name, part number, etc.)
- Detail information for Fabricated parts (may be used as spare parts) can be entered
- Detail description for the inventory part can be entered (will be helpful to the maintenance employees)
- Additional comments can be entered for each inventoried part (Ex: alternate parts that can be used)
- Manufacturer part number or User defined part numbers for item identification can be entered
- A link to the manufacturer and/or vendor website can be assigned for each inventoried part
- A picture, drawing, instructions and/or CAD files can be attached for each inventoried part
- OLE interface is provided to easily link to other applications (Ex: CAD drawings, Bill of materials, etc.)
- Multiple vendors can be assigned for each stored item or part (Primary Vendor and alternate vendors)
- More than one manufacturer can be assigned for each item or part (Primary and alternate manufacturer)
- On-Line Parts Catalog can be linked or assigned for each parts for additional information
Parts can be linked with the equipments/assets they are used on and can be easily displayed

Number of parts on-hand, on-order, on-reserve, etc. can be clearly identified and displayed easily

Parts can easily be identified as Hazardous and/or Critical and/or Fabricated material, etc.

Warranty information can be assigned to the parts (if a part has any warranty)

An MSDS can be attached, viewed and printed (if needed) for any part

Lead time for ordering and receiving the parts can be assigned for each part

Last price paid, standard price and average price of an item can be assigned for buyer reference

Default cost center or budget account can be assigned for each part (for budgeting purpose)

Purchasing and/or Detail Rebuild Instructions to an item can be assigned

A Physical count field can be assigned for accurate count in storeroom (to maintain accuracy)

Parts can be assigned to multiple storerooms and locations and tracked accurately

LIFO, FIFO and Weighted Average Inventory Valuation Methods can be utilized

Items can be classified by the UNSPSC (United Nations Standard Products and Services Code) Scheme

**Order/Receive Parts**

Economic Order Quantity, Re-Order Point and Safety Stock for every part can be established by individual storeroom
- Parts can automatically be reordered through user defined EOQ, ROP, Minimum Stock, etc.
- When quantities fall below minimum levels, parts can be replenished from vendor or from other storerooms
- Create purchase requisitions (or purchase orders) automatically when parts reach the minimum reorder point
- Create purchase requisitions (or purchase orders) automatically when parts reach end of shelf life
- Create purchase requisitions (or purchase orders) using the drag and drop methodology for ease of use
- Parts on-hand, on-reserve, on-order, etc. gets updated automatically when parts are received, reserved, etc.
- Order Units of Measure and Stored Units of Measure can automatically be converted (Ex: Kgs to Lbs)
- Just-in-time (JIT) can be utilized for Lead time to generate PO's, order parts and receive them
- Just-in-time (JIT) can be utilized for Lead time to reserve parts to work orders and pick them
- Identify out-of-stock items or make substitutions with alternate parts, vendor and/or store rooms
- Mandate a date/time stamped and system verified authorization before changes in inventory can be made
- Automatic Forecasted Requisitioning (AFR) and time availability information is available
- Use ABC analysis to assign inventory item priorities, governing frequency of physical item counts
➤ Store and display the last Purchase Order number and item cost for every part (helpful reference)

➤ Purchase Order is automatically closed, upon full receipt of Material (manual closing is allowed)

**Issue/Return Parts**

➤ Parts can be reserved by Work orders, Departments, Individual employees, Cost Accounts, etc.

➤ Parts information can be updated automatically linking parts to inventory, purchasing, work order, etc.

➤ Parts can be issued individually or in batches to Work Orders, Departments and/or Account Codes.

➤ Parts can be issued individually or in batches to Individual Maintenance employees

➤ Parts can be returned individually or in batches from Individuals, Work Orders, and/or Departments

➤ Tools (and similar products) can be Checked out (issued) and Checked in (returned back)

➤ Parts can be moved (issued and/or returned) between stores and updated automatically

➤ Serial and/or Lot Number can be assigned upon Material Receipt from vendors or from store rooms

➤ Serial and/or Lot Number can be assigned upon Issue and/or Return and/or Transfers

➤ Material Issue/Return, Warehouse Transfer, Cost & Unit Adjustment can all be performed from one screen
Adjustment against a Store and/or Work Order, etc. can easily be performed
(reasons need to be given)

User Defined Inventory Variance Acceptance Tolerances can be assigned to
each part

Purchase requests and/or Purchase orders can be generated manually or
automatically

View/Track Parts

Ability to view and track by many different part attributes (Ex: part name, part
number, etc.)

Inventory parts can easily be tracked (for Ex: qty on hand, on reserve, on order,
etc.) in multiple storerooms

All Stocked, Non-Stocked and Miscellaneous Parts can be tracked in multiple
storerooms

Inventory parts can be easily tracked, based on Serial and Lot Traceable number

Any outstanding orders (not received, partly received) can easily be tracked for
all the items

All transactions (ordered, received, reserved, etc.) can easily be tracked for all
the items

Track and dynamically update - Total Quantity Available, Quantity On Hand, On
Order, On Reserve, etc.

Track and dynamically update - Min. Quantity, Max. Quantity, EOQ, ROP, etc.

Track and view items, costs and balances by bin, lot, storeroom, etc.

Track item costs by last cost, average cost or user defined standard cost.

Track unit cost, carrying cost, total cost, last cost and date last purchased, etc.
- Track Inventory adjustment (Ex: after physical count) and reasons for inventory adjustment.
- Track quantity allocated to active work orders, completed work orders, etc.
- Track all the parts pulled from inventory (by date, work order, etc.)
- Track the history of issues, returns, purchases, cycle count variances, etc.

**Cost Details**

- Default Accounting profiles (Cost Centers) can be established for every part to be used in purchase orders
- Different costs like Last cost, Average cost, Standard cost, etc. can be assigned to every part
- Latest cost paid for any item can be easily displayed and compared with the standard cost/quoted cost
- Standard cost, etc. from more than one vendor (for the same part) can be assigned and stored
- Total cost associated with Storing Parts (inventory carrying cost) can be easily calculated
- Total cost associated with Ordering Parts (parts ordering cost) can be easily calculated
- Total cost associated with Receiving Parts (parts receiving cost) can be easily calculated
- Total quantities and total cost for every stored part can be easily calculated and retrieved
- Total cost of Inventory (cost of all stocked parts by store rooms) can be easily calculated
Total cost of Inventory Used per day, per week, per month, etc. can be easily calculated (by store rooms)

Total cost of inventory On-hand, On-reserve, On-order, etc. can be easily calculated for every part

Total inventory budget needed for next month, next year, etc. can be easily calculated based on previous usage

Inventory budget needed for next fiscal year can be projected/calculated using user-defined values

Allotted Inventory budget can be easily compared to the actual inventory cost spent in a month, year, etc.

**Inventory Reports**

- Reports can be created and displayed in various formats like Graphs, Charts, Tables, Pictures, etc.
- Detailed reports for Min. Stock, Max. Stock, EOQ, ROP, etc. can be created for every inventory part
- Detailed reports of parts usage per week, per month, etc. can be created for every inventory part
- Reports for Inventory Receipts, Inventory Issues, Inventory Stored, etc. can be created for every part
- Reports for Part Value, Part Shortages, List of Vendor Per Parts, List of Parts Per Vendor, etc. can be created
- Reports for parts used on any equipment during a certain time period can be easily created
- Account Summary reports - detailed report with information on every part in inventory can be created
Inventory Financial reports, Inventory Transaction reports, etc. can easily be created and displayed

Detail Supplier Performance Analysis Reports (user defined) can be created and displayed

Detail Inventory Audit reports (user defined internal audit) can be created, stored and displayed

Other Inventory Details

Inventory records from a previous database (Ex: Excel, Access, etc.) can be imported (speeds up implementation)

Inventory quantities and costs (after performing physical inventory) can be adjusted for accuracy

All Inventory details (quantities, cost, location, etc.) can be updated using the Barcode function

Inventory details can be analyzed and exported, printed or emailed as Word, HTML, Adobe, XML, and other formats

Able to use ABC analysis to assign inventory item priorities governing frequency of physical item counts

Economic order quantity (EOQ), Reorder Point (ROP), Min. Stock, etc. can easily be calculated for every part

Parts in Bill of Materials (BOM) for new equipment/asset can easily be compared with existing parts in inventory

Inventory parts can be deleted from the system, when these parts are no longer being needed or used

Able to maintain a History log for all the parts history, which can be easily retrieved when needed
**Purchasing Module**

Purchasing Module streamlines the parts procurement process while ensuring that the organization can efficiently and cost-effectively replenish spare parts and inventory materials. The Purchasing Module allows the user to manage the procurement cycle from creating a purchase requisition/order to placing an order, receiving, matching invoice and paying for the parts ordered. It helps to plan, execute and control all spare parts needed in Work Orders (both corrective and preventive) in an efficient and timely manner. Not having correct parts or materials for performing maintenance work can greatly affect and delay maintenance schedule, which can result in significant loss of revenue and can also result in loss of future business.

Purchasing Module can be used to record and control maintenance spare parts usage. The Purchasing module should automatically place items that have reached their reorder points on a purchasing requisition or purchase order. Both stocked and non-stocked inventory items can be purchased through the Purchasing module.

The Purchasing Module is required to purchase and receive parts and materials, either to be stored in the Inventory or to be used in a Work Order to maintain equipments in reliable condition. Purchasing Module is used to create purchase requisitions, purchase orders, quotation requests, receive parts, match invoice, etc. Purchase orders can be tracked to verify that all parts that were ordered have been received. Purchase order module should be capable of attaching detailed files to the purchase records, if needed.
Figure 23: Example of Purchasing Module (Source: Maintenance Coordinator)

These are some of the functions a Purchasing Module is typically used for:

- Create purchase requisition
- Approve purchase requisition
- Create purchase order
- Change or modify purchase orders
- Cancel purchase order
- Receive materials on purchase order
- Match invoice with purchase order
- Authorize payment of purchase order
- Create Request for Quotes
- Create Blanket Purchase Orders
Create Service Contracts

The Purchase Order Form is usually used to create and modify purchase orders, which are then issued to vendors to purchase parts. These are some of the details that should be available in the Purchasing Module:

- **PO Number:** This is an alphanumeric code that identifies this purchase order. This number can automatically be assigned by the system or can be user defined.

- **PR Number:** This is the purchase requisition number used to create the purchase order. If not applicable, this is left blank.

- **Part Number:** This number identifies each individual item on the purchase order. This number is usually assigned by manufacturer or vendor to identify the part. This is usually selected from the Inventory list. Once this part number is selected, related information like Part Description, Unit Cost, Vendor Name, Phone Number, etc. should automatically be filled in the appropriate boxes.

- **Part Description:** A brief description to correctly identify the part. System should automatically fill this box when the part number is selected.

- **Order Quantity:** The quantity of each item on the purchase order.

- **Unit Cost:** The current cost per unit of measure for this part.

- **Total Cost:** The total cost of all the parts on the purchase order. Total cost usually includes the tax, freight cost and all cost related to purchasing the parts.

- **Vendor Name:** The name of the vendor where items are being purchased.

- **Vendor Code:** The code number usually used to identify the vendor.

- **Contact Name:** The name of a contact person at the vendor’s location. System should supply this information if it has previously been entered in the system.

- **Vendor Phone:** The vendor’s telephone number (should be able to assign more than one phone number. Example: business phone, cell phone, pager, etc.)
- **Additional Info**: Space to enter additional information regarding the part, vendor, etc. should be available (Example: substitute part number)

- **Non-Stock Item**: System should allow entering an item that is not contained in the stored Inventory List. Non-stocked items should be clearly identified on the purchase order

- **Work Order Number**: If these parts have been ordered for a particular work order, the work order number should be entered

- **Date Ordered**: The date the Purchase order was issued to the vendor

- **Due Date**: The date these items are due to arrive. System should be able to provide due dates for each individual items on the purchase order

- **Requested By**: The name or identity of the person requesting this purchase

- **Approved By**: The name or identity of the person that approved this purchase

- **Purchased By**: The code or initials of the person placing this purchase order

- **Equipment Used**: This can be an optional field that will be helpful to the maintenance technician and others

- **Account**: This account number (cost center) will be used as the default account for each line item of the purchase order unless an account is entered for the individual line item in the Purchase Order

- **Taxable**: This Indicates if the items are taxable. If the items are taxable, the system will apply the specified default tax rate

- **Non Taxable**: This indicates that the item is not taxable and so no tax is added or specified for the purchase order

- **Tax Rate**: This field allows overriding the default tax rate. A tax rate other than the default tax rate can be specified

- **Freight Terms**: Any information that is applicable about the freight terms. Example: Name of the Freight Company to be used
- **Ship Via**: The shipping method. Example: FedEx overnight, UPS regular, etc. This helps in determining the shipping cost.

- **Ship To**: The name and/or location where the parts need to be shipped. Parts can be shipped to the appropriate location based on the purchase order.

- **FOB Point**: The location that ownership of items is transferred to the purchaser from the seller.

- **Freight Cost**: The amount charged for shipping and handling of the purchased parts from vendor to the purchaser.

- **Payment Terms**: Once all the parts are received, how does the vendor get paid? These payment terms can be assigned here. Example: Net 30 days.

- **Received Date**: The date the parts were received. System should have the ability to receive and accept full or partial quantity of parts ordered.

- **Received By**: The initials or code of the employee that received the parts. This helps to keep track of the parts received and who received the parts.

- **Received Cost**: The cost of the parts/items that have been received so far. This usually includes the cost of the items, plus tax, freight cost, etc.

- **PO Status**: This box shows the status of the Purchase order, Example: Open, Closed, Cancelled, etc.

- **Completed**: The completed check box tells the purchase order system that there will be no more activity with this purchase order. Only authorized personnel should be able to check mark this box.

- **Date Closed**: If the Purchase Order has been completed the date closed can be entered into this field.

- **Closed By**: The name or identity of the person who closed this purchase order.
These are the detail questions (features and functions) that need to be evaluated for selecting the right "Purchasing Module" in the CMMS system. These detail questions are listed in SELECTCMMS application under the "Purchasing Module". The company can select the right features and functions needed in their "Purchasing Module" by reviewing these questions and selecting the appropriate response (Must Have, Important, Nice to Have, Not Important) based on their company's requirements.

Create Purchase Requisition

- Purchase requisition can automatically be generated based on the reorder point or can be manually generated
- Users outside the maintenance department can submit purchase requests for parts to be ordered by the system
- Unlimited number of parts and/or services can be added to the purchase request and purchase order
- Purchase requisition can be generated (automatically/manually) and emailed to appropriate people for approval
- Purchase requisition can be generated (automatically/manually) and routed appropriately for multi-level approvals
- Alternate approval routing can be created for the purchase requisition (for people on vacation/sick, etc.)
- Purchase requisition can be electronically signed for approval or non-approval (reasons can be provided)
- Email notification can automatically be sent to requester after the purchase request is approved or not approved
- Appropriate dollar limits for approving purchase requests can be assigned (management decision)
- Able to create purchase requisitions (and purchase orders) for parts, contract labor, services, etc.
- Able to create purchase requisitions from Purchasing Module or Inventory Module or Work Order Module
- Able to automatically generate purchase requisitions by selecting items/parts from the inventory module
- Able to select parts (stocked parts) from a dropdown list (filters provided) to add to the purchase requisition
- Able to display the reorder list and vendor list to drag and drop to line items list on Purchase Requisitions
- Able to create and store standard descriptions (parts, vendors, etc.) for use on Purchase Requisition
Create Purchase Order

- Able to automatically create purchase orders (with all details) from approved purchase requisitions
- Able to make modification to purchase order after purchase requisition has been approved (should be tracked)
- Able to attach documents, files, pictures and any other details to the purchase order
- Able to automatically combine parts from many purchase requisition onto a single purchase order (based on same vendor)
- Able to automatically create multiple purchase orders from a single purchase requisition (based on parts/vendors)
- Able to create purchase orders in batch (create several PO) from line items of multiple purchase requisitions
- Purchase order number can automatically be created by the system or can be entered by the user
- Vendor codes can be created for all vendors (with some exceptions) doing business with the company
- Able to list approved vendors and manufacturers for each part and know exactly where to purchase a part
- Able to create Blanket Purchase Orders (purchase order agreement) to purchase parts over certain time period
- Able to create Blanket Purchase Orders with expiration date, dollar amount, etc. and keeping track of dollars remaining
- Able to create purchase orders for short term and long term service/contract maintenance
➢ Able to create special purchase orders by entering item descriptions as line items for parts not in inventory database

➢ Purchase orders can be faxed and/or emailed to vendor (automatic email reply from vendor can be received)

➢ Purchase order can be customized and printed, based on the user’s requirements (attach company details)

➢ When printing purchase orders, Company’s logo can be printed (at certain location) on the purchase order

➢ When printing purchase orders, Purchase Order Labels (as an option) can automatically be printed

➢ Able to easily establish and create complete Vendor Information for Purchasing, Accounts Payable, etc.

Track PO, PR, Invoice

➢ Able to automatically add and track the sales tax, shipping costs, etc. for each purchase order

➢ Able to automatically calculate and track dollars spent on Purchase Orders by department, date, work order, etc.

➢ Able to automatically calculate and track total dollars spent on individual items per month, per year, etc.

➢ Able to automatically calculate and track total dollars spent on individual vendors per month, per year, etc.

➢ Able to calculate and track total dollars spent on any contract/services per contractor, per month, etc.

➢ Able to automatically calculate and track total dollars spent on all Purchase Orders in a fiscal year
➢ Able to track Purchase Requisition/Purchase Orders approved, rejected, canceled, etc. during certain time period

➢ Able to easily track the purchase order status as parts on order, parts partially received, fully received, etc.

➢ Able to track parts received on time, late delivery, incorrect parts, damaged parts, returned parts, etc.

➢ Able to correctly track parts received in multiple storerooms from a single purchase order

➢ Able to track packing slip, invoice number, shipments, receipts, received by, history log, etc.

➢ Able to generate purchase order details, which tracks and matches PO number with the Invoice number

Request for Quotes/Tenders

➢ Able to create Request for Quotation (RFQ) for individual bids or multiple vendors bids on materials/services

➢ Able to modify Request for Quotation (RFQ) after it has been sent out and keep track of the changes

➢ Able to store and keep track of all the Vendor Responses based on Request For Quotation (RFQ)

➢ Able to request more details from Vendors after their initial response for RFQ and keep track of the changes

➢ Able to process all Vendor Responses and select the best vendor for the RFQ (User defined reasons provided)

➢ Able to automatically transfer details from Request For Quotation (RFQ) to a Purchase Order
All Vendor Responses to all Request for Quotations, can be stored in a history folder and easily retrieved

**Receive/Return Goods**

- Able to track receipt and/or return of all items purchased through the Purchasing module
- System can accept quantities different to that which was due and quantities updated accordingly
- Each delivery received against a Purchase Order, the system can generate a Goods Received Note (GRN)
- GRN can be used as an Invoice matching capability, to manage and control the receipt of inventory parts
- GRN can also be used to accept or reject the received quantities and clear them for payment
- An item received not only updates the purchase documents, but also updates inventory levels
- Able to create an automatic Return Goods Authorization (RGA) for parts to be returned to vendor
- RGA can allow the user to return goods to a vendor after they have been entered as received
- Bar codes can be printed at time of receipt to easily update the inventory quantities, part details, etc.
- Able to notify maintenance (or requester) about any parts received through the Work Order Module
**Cost/Invoice Match**

- Able to easily monitor and compare last price, quoted price, standard price, average price, etc.
- Able to create purchase orders using budgets assigned to Work Orders and/or General Ledger Account
- Able to use Invoice Matching to complete purchasing cycle for seamless interface with enterprise financial applications
- Able to automatically perform, two-way (PO/Invoice) and three-way (PO/Receipt/Invoice) matches.
- Able to define an unlimited number of currencies to track purchases/services from different countries
- Able to automatically convert different currencies to default currency (conversion table provided)
- Able to optimize purchasing efficiency with electronic commerce (saves cost, time and easy to keep track)

**Purchasing - Other Details**

- Purchasing module can be integrated with company's financial solution to facilitate real-time budgeting, invoicing, etc.
- Interface with ERP, can allow ERP to control the cost functions yet keep the ordering in Maintenance department
- Able to analyze vendor performance (create easy to read tables/graphs) for ordering parts/services
- Able to process part receipts (and/or returned) via the Mobile Maintenance Module (Using PDA)
Able to customize purchase orders via the Crystal Reports interface (if Crystal Report application is present)

Able to generate complete Blanket Purchase Order Release History (date, cost details, quantities details, etc.)

Able to Track purchase order activity history, receipts, returns, supplier quotes, cost changes, etc.

Detail reports can be created for Supplier Performance, Parts Usage, Inventory Valuation, Parts Listings, etc.

**Reporting Module**

A report is an account (chart, table, graph, etc.) that is prepared, presented or delivered, usually in an organized form. The "Reporting Module" in a CMMS system plays an important role by providing details of maintenance related information in an organized form to the management. With the Reporting Module, management can get the needed output from all the data collected in the CMMS system, helping them to make good decisions for the company.

In a typical CMMS system, different modules collect and record all data pertaining to maintenance of equipments/assets. Maintenance related information like equipment downtime, failure cause, repair time, labor cost, materials used, maintenance cost, and inventory cost, etc. are collected and usually stored in the history folders. The Reporting Module helps in extracting this information and creating user-defined reports that not only justify maintenance expenses, but also are extremely important for projecting future maintenance needs. Using this information from the Reporting Module, management can analyze maintenance history, enhance equipment reliability, minimize downtime, improve safety, generate regulatory documentation, reduce inventory budget and increase overall productivity and profits. These reports also provide maintenance
managers with information to judge the quality and success of their maintenance
deptartment and provide upper management with necessary information like equipment
utilization, maintenance productivity, cost savings, etc. Many wide ranging statistical
data and reports should be readily available from any CMMS system. An important
feature for any Reporting Module in a CMMS system is the ability to customize reports
based on the company's needs. (Including layout, data, frequency, etc.). By generating
user-defined reports, management can track how efficient and productive their
organization is in responding to corrective and preventive maintenance issues.

Usually all CMMS systems use a report generator of some sort to produce the
reports. There are numerous report writers and decision support software available, from
both the manufacturers of databases and business intelligence tools. For example,
Oracle, Sybase, IBM, Seagate (Crystal Reports) and Informix all provide report-writing
solutions as standalone or integrated applications. Most CMMS systems usually come
with some standard reports. But usually, the specific needs of each company will ensure
that these will be of limited value. One of the most important factors in choosing any
CMMS system should be its ability to customize and produce various reports; exactly the
way the company requires it. Ideally, the system should allow the company to customize
and create reports with little or no help from the vendor. Along with many customized
reports, the system should be able to create some of these important reports:

- Mean Time Between Failure (MTBF) report
- Mean Time To Repair (MTTR) report
- Failure and Repair Analysis report
- Equipment Cost Analysis report
- Life Cycle Cost Analysis report
- Productive Time Analysis report
- Technician Scheduling Analysis report
Figure 25: Example of Reporting Module Screen (Source: iMaint CMMS)

Figure 26: Example of Reporting Module Screen (Source: MaintiMizer CMMS)
These are the detail questions (features and functions) that need to be evaluated for selecting the right “Reporting Module” in the CMMS system. These detail questions are listed in SELECTCMMS application under the “Reporting Module”. The company can select the right features and functions needed in their “Reporting Module” by reviewing these questions and selecting the appropriate response (Must Have, Important, Nice to Have, Not Important) based on their company’s requirements.

- Built-in reporting module (not third party reporting software) is used to create customized reports
- Reporting Module is fully integrated with all other CMMS modules to create customized reports
- Reporting Module can display key information in an easy-to-use graphic, chart, table or any other format
- Reporting Module can customize data, examine trends and create sub-reports in a variety of formats
- Custom reports can be created using any major third party reporting tool – Ex: Crystal Reports, Microsoft Access, etc.
- Reports can be saved and/or exported to many different applications – Microsoft Word, Excel, etc.
- Able to drag and drop to create column headings and generate statistical reports using any numerical analysis
- Reporting can drill down to move from an enterprise-wide view to individual plant and even department levels
- System comes standard with band reporting engine with complex logical and embedded report functionality
- Reporter data engine can handle complex table relationships, including parent, child, grandchild, etc.
➤ Reporter's design interface makes it easy to customize the report, until the output
looks the way user wants it
➤ Many user-defined reports can be created utilizing information generated by
different CMMS modules
➤ Many user-defined reports can be created utilizing information from CMMS
modules and other enterprise applications
➤ Reporting module supports line, rectangle, ellipse, text, field, image, graph, and
many embedded objects
➤ Report objects can be customized with borders, shading, colors, fonts, and
shadows to create professional looking reports
➤ Reporting module can support at least three report types: standard listing,
column-label and cross-tab reports
There are many other modules (Optional Modules), which help to enhance the effectiveness of the CMMS system. Very few CMMS systems available in the market today, contain all these modules. In a few CMMS systems, some of these optional modules are integrated with the main modules. (E.g. Warranty Module is integrated into Equipment Module). Optional modules can add significant benefits to the overall maintenance related activities in the organization. These modules can help to increase the efficiency and reduce overall cost and time to perform maintenance related activities. These optional modules should be carefully evaluated and selected based on the requirements of the organization. Some important optional modules are discussed in the following sections. The different optional modules commonly used in many CMMS systems are:

- Analysis Module
- PDA Interface Module
- Security Module
- Scheduling Module
- Vendors Module
- Customers Module
- Receiving Module
- Document Module
- History Module
- Warranty Module
- Web Browser Module
PDA Interface Module

PDA Interface Module is also called as “Mobile Maintenance Module”. Organizations need a mobile maintenance module that will work in tandem with the main CMMS system. Detail work order information like labor cost, material cost, equipment downtime, maintenance tasks and maintenance history need to be captured effectively without extensive and redundant data entry. Accurate work orders form the backbone for effective mobile data management. Maintenance management should be able to access the appropriate information quickly, issue work orders from the field, and effectively track maintenance tasks, labor, materials, work order history, etc. for all work orders.

A Mobile maintenance module should enable all these important job tasks and much more. Maintenance technicians should be able to use a handheld Palm Pilot to access critical work order information; materials and tools required, equipment history, failure reporting, etc., and then enter pertinent information for actions completed including; labor time, materials used, failure reporting, or description of work completed. This process enables companies to accurately monitor productivity for an individual or team, and relay that information to the corresponding departments. Mobile maintenance should avoid piles of data entry paperwork.

These are some of the most important Benefits of mobile maintenance module:

- Increased first-time fix rates and reduced downtime.
- Real-time review and evaluation of plant conditions.
- Distribution of work assignments to technicians in the field to reduce travel time from the shop to the job, thereby increasing worker efficiency.
- Immediate attention to emergency work orders and reduction of backlog.
- More accurate capture of time, labor, materials, etc. for accurate and effective customer billing.
- Elimination of duplicate and or redundant data entries for the same work order
- More accurate and timely data for the technician, which reduces maintenance expenses for the companies
- More effective distribution of safety information. Safer workers equipped with the proper tools and safety gear.

These are the detail questions (features and functions) that need to be evaluated for selecting the right “PDA Interface Module” in the CMMS system. These detail questions are listed in SELECTCMMS application under the “PDA Interface Module”. The company can select the right features and functions needed in their “PDA Interface Module” by reviewing these questions and selecting the appropriate response (Must Have, Important, Nice to Have, Not Important) based on their company’s requirements.

**Mobile General Info**

- Mobile Device comes with the software already installed and also with a built-in barcode reader
- Mobile Device comes with the software already installed, but without a built-in barcode reader
- Mobile Device is compact and lightweight – which can be carried around in a shirt pocket or can be belt-holstered
- Different types of Mobile Devices can be used for mobile maintenance (not just the ones provided by software vendor)
- Mobile Devices can communicate with main database using docking cradles (batch download or upload)
- Mobile Devices can communicate with the main database using wireless communication (real time update)
Mobile Devices can be used as cell/mobile phones to communicate with other team members in real time.

Work requiring immediate attention, can be transmitted to mobile device using standard wireless protocols.

On Mobile Devices, screens can be configured by hiding fields, arranging location of fields, setting up default values, etc.

Mobile Devices can be customized for specific user groups, that shows exact screens and fields they need.

Mobile Device can distinguish user privileges, enabling interface to be configured specifically to each user's needs.

Mobile Device interface are designed to allow for a true two-way, real-time exchange of data with the main database.

Mobile Device has complete access to all the modules in the CMMS system (just like on a desktop).

Mobile Device can be configured to have user-defined access to the modules in the CMMS system.

Web access is available on Mobile Device, which can be used for searching Web for maintenance information, parts, etc.

**PDA Work Order Management**

All assigned work orders can be downloaded on Mobile Device, completed and synchronized back to main database.

Mobile Device can be placed in its cradle and updated information can quickly be transferred back to main database.

All assigned work orders can be displayed on Mobile Device, completed and updated in real time (using wireless).
- Mobile Device has complete access (create, modify, delete, etc.) to the CMMS work order module
- All work order related information (materials, instructions, etc.) can easily be displayed on Mobile Device
- All task details related to Preventive Maintenance can easily be displayed on the Mobile Device
- Each task for the PM can be checked off on the Mobile Device, after they have been completed
- By clicking on an individual task, more details can be read and meter readings can be entered (if applicable)
- Work order can be checked off as complete (and can be closed) after it has been completed using Mobile Device
- All required parts, tools and other detailed information can be displayed on the Mobile Device (to complete work)
- New work requests can be created and entered directly into the system using the Mobile Device
- New work orders can be created and entered directly into the system using the Mobile Device
- Existing work orders can be modified, reassigned, cancelled, etc. directly on the Mobile Device
- New work requests can be signed electronically using Mobile Device and converted to work orders
- New work orders can be emailed (or communicated) to appropriate people using Mobile Device for immediate attention
- Work order information displayed on Mobile Device can be read only (information cannot be modified)
➤ Meter readings on equipment/assets can be recorded with automatic notification if reading exceeds allowable limit.

➤ Mobile Device automatically provides appropriate meter name, unit of measure, etc. to increase accuracy of data

➤ Work order details like materials used, start time, end time, comments, etc. can be entered directly on Mobile Device

➤ Time worked on an assignment can be tracked using an automatic start and stop feature available on Mobile Device

➤ Historical information referencing last work performed on equipment can easily be accessed on the Mobile Device

➤ Historical information referencing all work performed on equipment can easily be accessed on the Mobile Device

➤ Historical information referencing work performed on similar equipments can easily be accessed on the Mobile Device

**PDA Inventory Management**

➤ Using Mobile Device – Parts/Materials can be issued, received, returned, etc. for accurate inventory management

➤ Using barcode scanning on Mobile device, inventory can be tracked and updated on real time basis

➤ Using Mobile Device - New inventory records can be created for equipments and transferred quickly by docking

➤ Using Mobile Device - New inventory records can be created for equipments and updated in real time using wireless

➤ Physical part inventories and parts records can be updated using mobile device in real time basis
➤ Physical inventory count list can be downloaded on the Mobile Device for easy counting
➤ Parts received from the vendor can be updated using Mobile Device for real time inventory
➤ Using Mobile Device - Parts can be transferred from one location to another and tracked accurately
➤ Using Mobile Device - Parts issued to work orders and/or maintenance employee's hours can be tracked accurately

**Analysis Module**

These are the detail questions (features and functions) that need to be evaluated for selecting the right "Analysis Module" in the CMMS system. These detail questions are listed in SELECTCMMS application under the "Analysis Module". The company can select the right features and functions needed in their "Analysis Module" by reviewing these questions and selecting the appropriate response (Must Have, Important, Nice to Have, Not Important) based on their company's requirements.

➤ Clear and easy to read Analysis results can be presented both in table/chart and graphical format
➤ Results of the analysis can be exported to many applications, for example: Excel, Word, etc.
➤ Analysis reports, tables and graphs can be generated and printed based on users requirements
➤ Analysis tool can be configured to run manually or automatically using for example: An automation timer
The type of failure to be used in reliability analysis can be clearly defined. For Ex:
- Failure over 10 minutes
- Failure history including symptoms, cause of failure, and action taken can be easily reviewed and analyzed
- Mean time between failure (MTBF), Mean time to repair (MTTR), etc. can be reviewed and analyzed
- Reliability analysis on individual equipment items and their failure causes can be performed, to help in selecting proper PM tasks and PM task intervals
- Analysis Module can analyze maintenance employee’s skills vs. the tasks needed to complete PM tasks
- Analysis Module can analyze – If equipment failure rate is getting better or worse over certain time period?
- Analysis Module can analyze – How long (in terms of hrs, days, etc.) can an equipment item run before it fails?
- Analysis Module can analyze – What is the percentage chance of equipment failure during a specified time period?
- Equipment Failure and Down Time Analysis can be customized based on the users requirements (Ex: down time by hours, percentage, efficiency, etc.)
- PM Analysis can be customized based on the users requirements (Ex: PM completion time, completion rates, etc.)
- Work Order Analysis can be customized based on the users requirements (Ex: completed on time, late start, late finish, etc.)
- Inventory can be Analyzed, Audited and Optimized based on users requirements (Ex: Parts on hand, Inventory cost, etc.)
- Inventory usage can be analyzed based on the users requirements (E.g.: usage by date, storeroom, cost, etc.)
Security Module

These are the detail questions (features and functions) that need to be evaluated for selecting the right "Security Module" in the CMMS system. These detail questions are listed in SELECTCMMS application under the “Security Module”. The company can select the right features and functions needed in their “Security Module” by reviewing these questions and selecting the appropriate response (Must Have, Important, Nice to Have, Not Important) based on their company’s requirements.

Able to provide a helpful interface to easily setup access rights for all system users

- Able to setup different levels of access for each user Ex: read only, read and write, full access (including delete), etc.
- Able to setup different access rights to users for different modules, based on users needs
- Able to provide different items within different modules, which can be check marked for access
- Able to setup access rights to the system down to the form, field, report level, etc.
- Able to add, edit and/or delete users access rights to the system by authorized users
- Able to setup security and access rights to login into the system via the Web browser
- Able to setup security and access rights to login into the system via PDA Interface module
- Able to encrypt all user names and passwords for all different levels of access
- Able to setup workstations where employees can only enter work requests, purchase requests, etc.
- Able to setup workstations where employees can check status of their work requests, purchase requests, etc.
- Able to set preferences (default settings) for how dates, times, monetary (currency) values, etc. are displayed
- Able to change preferences (by authorized personnel) for how dates, times, monetary values, etc. are displayed
- Able to setup default cost centers for equipments, departments, user groups, parts, etc.
- Able to customize the menu structure to add or hide areas of the system for individual users
- Able to customize data labels (used on the screens) and report titles for individual users
- Able to configure menu structure to different modules, for individual users
- Able to establish and maintain security between system, database and the server
- Able to configure a schedule for automatic backup of database system
- Able to generate detail security reports for analysis and decision support
- Able to categorize users with predefined user groups for easy tracking
- Able to track and collect detail information to see how the system is being used
- Able to maintain, track and retrieve complete audit trail of all user activities
- Able to establish approval chains, for purchase requests, work requests, etc.
- Able to establish vendor specific details (shipping criteria, payment terms, sales tax, etc.)
- Able to provide access to the vendor specific details, to the appropriate users
- Able to configure custom reports and KPIs (Key Performance Indicators)
Scheduling Module

These are the detail questions (features and functions) that need to be evaluated for selecting the right “Scheduling Module” in the CMMS system. These detail questions are listed in SELECTCMMS application under the “Scheduling Module”. The company can select the right features and functions needed in their “Scheduling Module” by reviewing these questions and selecting the appropriate response (Must Have, Important, Nice to Have, Not Important) based on their company’s requirements.

Scheduling Module can create schedules for preventive maintenance as well as corrective maintenance

➤ Scheduling Module can create schedules for equipment/assets, using technicians and/or contractors

➤ Work orders assigned/unassigned to technicians can be grouped into an easy-to-read, scrolling calendar format

➤ Schedules can be viewed by month, week or day, displaying total work orders and assigned technicians

➤ Color-coded bars can visually display scheduled/unscheduled work orders, holidays, technician availability, etc.

➤ The displayed schedule of work orders, can be exported to different applications like Microsoft excel, etc.

➤ Scheduling Module can allow maintenance planner to view, active work orders, unassigned work orders, etc.

➤ Scheduling Module can allow to view, future preventive maintenance work orders by week, month, etc.

➤ Scheduling Module can categorize work orders by type and includes detail work order information
The Scheduling Module can allow users to set resource levels and develop "what-if" scenarios.

A hierarchy of schedules can be created and work “dragged and dropped” from one schedule to another.

Scheduler can provide a way to graphically schedule PMs and work orders while minimizing overtime.

Tasks shown as unscheduled can be assigned to available technicians right through the calendar view.

Scheduling view should help to identify schedule conflicts, and appropriate action can be taken to rectify.

Work order tasks assigned to technicians can be clicked and edited or reassigned to other technicians.

Work hours from one technician or contractor can be dragged and dropped to another technician or contractor.

Scheduled dates (start/end) for the work order can be changed, by clicking on the appropriate date column.

Total work orders for the day, week or month can be viewed (or printed) by assigning a range of dates.

Work order assignments can be grouped and classified as per department, production lines, clients, etc.

Scheduling Module allows to view only those work orders for a certain equipment, technician, location, etc.

Schedules can be viewed by work assigned to a particular supervisor, department, location, building, etc.
CONCLUSIONS AND FUTURE RESEARCH

Conclusions

When properly selected and implemented, CMMS is one of the most powerful cost reduction tools in any organization. However in reality, many CMMS implementations fail, rather than achieve success. Selecting the right CMMS system can greatly influence the overall success of the CMMS implementation. However, selecting the right CMMS system is not an easy task. There are hundreds of vendors providing solutions on a variety of platforms. With more than 200 CMMS systems to choose from, selecting and implementing the right CMMS system, based on the operations and maintenance requirements of a company can be a very daunting task. However, by developing detailed system requirements that match the company's operations and maintenance processes, one can ensure the best fit. More detailed requirements based on all available features in each CMMS modules, can allow for better opportunities to ensure a proper fit. This approach also reduces the need to customize the software, and the return on investment (ROI) can be faster as the system is implemented with greater opportunities for full usage.

When selecting a CMMS, it is important that the software features and functions available in the CMMS system will support all maintenance related activities. The maintenance process and the software features must be compatible to perform the maintenance function smoothly and effectively. It is also important that the CMMS selected is user friendly and helpful to all the concerned people.

This research provides guidelines for CMMS selection and also helps in identifying and selecting the right features and functions needed in a CMMS system, for successful implementation. A CMMS Selection Tool (known as SELECTCMMS) was developed using Visual Basic software, to provide guidelines in selecting the right
features and functions in a CMMS system. SELECTCMMS will list out the various features and functions currently available in many CMMS systems. In a CMMS system, many different "Modules" (example: Equipment module, Work order module, etc.) are utilized to plan, schedule, execute, track and control the equipment maintenance. Each module has various features and functions that determine how CMMS systems are utilized for efficient maintenance management. Using SELECTCMMS, the CMMS selection team can select all the features and functions needed for cost efficient maintenance. A detailed CMMS specifications document in Microsoft Word is automatically created, based on the features and functions selected. This detailed CMMS specifications document can be utilized to solicit proposals from different vendors to evaluate, select and implement the right CMMS system to enhance the reliability of equipments, increase productivity of maintenance department and generate higher profits for the organization.

**Future Research**

The success of any CMMS implementation greatly depends on selecting the right CMMS system, setting up an efficient maintenance practices and procedures, getting support of the top management for maintenance activities and providing effective training to develop a good team. This research has focused on the need to select the right CMMS system for successful implementation. For the overall success of the company and in particular the maintenance department, these are some of the recommendations for future research for successful implementation of CMMS systems.

- Developing effective maintenance practices and procedures during the process of selecting the right CMMS system
- Utilizing CMMS to setup an efficient and cost effective Preventive Maintenance and Predictive Maintenance programs
- Utilizing CMMS to setup an efficient and cost effective Total Productive Maintenance and Reliability Centered Maintenance Programs
- Identifying key factors in how the Web based CMMS system can influence the implementation and future of the CMMS/EAM system.
APPENDIX A

CMMS Software’s Researched for this Study

These are some of the most popular CMMS systems that were reviewed and researched for this study. The CMMS systems are arranged in alphabetical order:

<table>
<thead>
<tr>
<th>Company Website</th>
<th>CMMS Software</th>
</tr>
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<tr>
<td><a href="http://www.fmssystems.co.uk">http://www.fmssystems.co.uk</a></td>
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APPENDIX B

Introduction to Reliability and Maintainability

The information below is from the notes on Reliability and Maintainability website, maintained by Dr. Houshyar Azim, at Western Michigan University.

Reliability and Maintainability (R&M) are vital characteristics of products & manufacturing machinery and equipment that enable U.S. manufacturers to be world-class competitors. Reliability consideration plays an increasing role in virtually all the engineering disciplines. As the demand for the systems that perform better and cost less increase, there is great need to minimize the probability of failures, whether the failures simply increase costs and inconvenience, or gravely threaten the public safety. In the broad sense, reliability is associated with dependability, with successful operation, and with the absence of breakdowns or failures.

From the product point view, customer relies on a product that performs its intended function with no failure. From the manufacturing point of view, efficient production planning depends on a process that yields high quality parts at a specific rate without interruption. Predictable reliability and maintainability of the manufacturing machinery and equipment is a key ingredient in maintaining production efficiency and the effective deployment of Just-in-Time principles. In both cases, improved reliability and maintainability of a product/equipment lead to lower total life cycle costs that are necessary to maintain the customer satisfaction competitive edge.
Basic Definitions of Reliability & Maintainability

Reliability is the probability that a product (or equipment) can perform continuously without failure, for a specified interval of time when operating under stated conditions. Increased reliability implies less failure of an equipment and consequently less downtime and loss of production.

Maintainability is a characteristic of design, installation and operation, usually expressed as the probability that a machine can be restored to specified operable condition (returned to a serviceable state) within a specified interval of time when maintenance action is performed in accordance with prescribed procedures and resources.

Availability is the probability that at any time, the system is either operating satisfactory or is ready to be operated on demand, when used under stated conditions.

Life Cycle Cost (LCC) refers to the total cost of a system during its operational life. LCC is the sum of non-recurring costs plus operation and support costs. Operation and support costs typically consume about 50% of the total LCC.

Reliability + Maintainability => Availability

Mean Time Between Failures (MTBF): The average time between failure occurrences. The sum of the operating time of a machine, divided by the total number of failures.

Mean Cycle Between Failures (MCBF): The average cycles between failure occurrences. The sum of the operating cycles of a machine divided by the total number of failures.

Mean Time To Repair (MTTR) is the average time to restore machinery or equipment to specified conditions.

Failure Rate: Number of failures per unit of gross operating period in terms of time, events, cycles, or number of parts.
Reliability: $R(t)$ indicates reliability at time $t$, where $t$ is the duration of failure-free operation of the equipment.

$\text{MTBF} = \frac{\text{Operating time}}{\text{Total number of equipment failures}}$

Failure rate $= \frac{\text{Total number of equipment failures}}{\text{Operating time}}$

$\text{MTBF} = \frac{1}{\text{Failure Rate}}$

During the design and development phase, the availability ($A$) is calculated from the design data using:

$A = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$

During the later phases of the life of the product, the availability is calculated using the actual data on operating time and downtime; that is:

$A = \frac{\text{Operating Time}}{\text{Net Available Time}}$

Emphasizing R&M practices during the conception and development stages can lower the total LCC. By using R&M to minimize stress (electrical, mechanical, etc.), the equipment will be less prone to failure during operation. This results in a decrease of the operation and support costs that account for the bulk of total Life Cycle Cost (LCC).

A slight increase in spending to incorporate R&M practices during the conception and design stages can dramatically lower the operation and support costs. It is important to consider R&M at the early stage of a program. Studies have shown that as much as 95% of LCC is determined during conceptual and development stages. Once new product (equipment) has reached the build stage, therefore, only 5% opportunity remains to effectively improve the reliability or maintainability of the product (or equipment).

*Major Benefits of Reliability and Maintainability*

Highly reliable and maintainable production machinery offers the means for producing consistently high quality products at lower costs and at higher output levels. Successful application of R&M techniques has a very positive effect on employee morale and pride.
since the reduction in downtime also results in significant reduction in employee stress and frustration.

**Major Benefits to the User**

- Higher machinery & equipment availability
- Unscheduled downtime reduced/eliminated
- Reduced maintenance costs
- Stabilized work schedule
- Improved J-I-T performance capability
- Improved profitability
- Increased employee satisfaction
- Lower overall cost of production
- Higher quality parts and product
- Less need for in-process inventory to cover downtime
- A competitive edge in the marketplace

**Major Benefits to the Supplier**

- Reduced warranty costs
- Reduced build costs
- Reduced design costs
- Improved customer relations
- Higher customer satisfaction
- Increased understanding of productions
- Increased sales volume
- Increased employee satisfaction
- Improved status in the marketplace
These are some terms that are commonly used in maintenance management.

**Asset** - Either an equipment, building, or system. It is the basic unit of maintenance.

**Asset Management** - the systematic planning and control of a physical resource throughout its life. This may include the specification, design, and construction of the asset, its operation, maintenance and modification while in use, and its disposal when no longer required.

**Asset Register** - a list of all the assets in a particular workplace, together with information about those assets, such as manufacturer, vendor, make, model, specifications etc.

**Availability** - the proportion of total time that an item of an equipment is capable of performing its specified functions, normally expressed as a percentage. It can be calculated by dividing the equipment available hours by the total number of hours in any given period.

**Available Hours** - the total number of hours that an item of equipment is capable of performing its specified functions. It is equal to the total hours in any given period, less the downtime hours.

**Average Life** - how long, on average, a component will last before it suffers a failure. Commonly measured by Mean Time Between Failures (MTBF).

**Backlog** – any work, which has not been completed by the nominated 'required by date'. The period for which each Work Order is overdue is defined as the difference between the current date and the 'required by date'.

Bill of Materials (BOM) A list of all the parts and components that make up a particular asset.

CMMS - Computerized Maintenance Management System. A computerized system to assist with the effective and efficient management of maintenance activities through the application of computer technology.

Condition Based Maintenance. An equipment maintenance strategy based on measuring the condition of equipment in order to assess whether it will fail during some future period, and then taking appropriate action to avoid the consequences of that failure.

Condition Monitoring - the use of specialist equipment to measure the condition of equipment. Vibration Analysis, Tribology and Thermography are all some examples of Condition Monitoring techniques.

Corrective Maintenance – Also called as Breakdown Maintenance. Any maintenance activity, which is required to correct a failure that has occurred or is in the process of occurring. This activity may consist of repair, restoration or replacement of components.

Craftsperson – Also called as Tradesperson. A skilled maintenance worker who has typically been formally trained through an apprenticeship program.

Downtime - the time that an item of equipment is out of service, as a result of equipment failure. The time that an item of equipment is available, but not utilized is generally not included in the calculation of downtime.

Economic Life - the total length of time that an asset is expected to remain actively in service before it would be cheaper to replace the equipment rather than continuing to maintain it.

Equipment Maintenance Strategies - the choice of routine maintenance tasks and the timing of those tasks, designed to ensure that an item of equipment continues to fulfill its intended functions.
Failure Code - a code typically entered against a Work Order in a CMMS, which indicates the cause of failure (e.g. lack of lubrication, metal fatigue etc.)

Failure Consequences - a term used in Reliability Centered Maintenance (RCM). The consequences of all failures can be classified as either being Hidden, Safety, Environmental, Operational, or Non-Operational.

Failure Effect - a description of the events that occur after a failure has occurred as a result of a specific Failure Mode. Used in Reliability Centered Maintenance, FMEA and FMECA analysis.

Infant Mortality - The relatively high conditional probability of failure during the period immediately after an item returns to service.

Key Performance Indicators (KPI) A select number of key measures that enable performance against targets to be monitored.

Life Cycle Costing (LCC) A process of estimating and assessing the total cost of ownership of an asset. The total purchase cost, operation cost and maintenance cost are usually used to calculate its projected equipment life. Typically used in comparing alternative equipment design or purchase options in order to select the most appropriate option.

Maintainability - the ease and speed with which any maintenance activity can be carried out on an item of equipment. May be measured by Mean Time to Repair (MTTR). Is a function of equipment design, and maintenance task design (including use of appropriate tools, jigs, work platforms etc.)

Maintenance - any activity carried out on an asset, in order to ensure that the asset continues to perform its intended functions.

Maintenance Engineering - a staff function whose prime responsibility is to ensure that maintenance techniques are effective, that equipment is designed and modified to improve maintainability, that ongoing maintenance technical problems are investigated,
and appropriate corrective and improvement actions are taken. Used interchangeably with Plant Engineering and Reliability Engineering.

**Maintenance Schedule** - a list of planned maintenance tasks to be performed during a given time period, together with the expected start times and durations of each of these tasks. Schedules can apply to different time periods (e.g. Daily Schedule, Weekly Schedule etc.)

**Maintenance Strategy** - a long-term plan, covering all aspects of maintenance management, which sets the direction for maintenance management, and contains firm action plans for achieving a desired future state for the maintenance function.

**MTBF** - Mean Time Between Failures. A measure of equipment reliability. Equal to the number of failures in a given time period, divided by the total equipment uptime in that period.

**MTTR** - Mean Time To Repair. A measure of equipment maintainability. Equal to the total equipment downtime in a given time period, divided by the number of failures in that period.

**Operating Hours** - the length of time that an item of equipment is actually operating (per day, week, month or year).

**Operational Consequences** - a failure has operational consequences if it has a direct adverse impact on operational capability (lost production, increased production costs, loss of product quality, or reduced customer service)

**Operational Efficiency** - used in the calculation of Overall Equipment Effectiveness. The actual output produced from an asset in a given time period divided by the output that would have been produced from that asset in that period, had it produced at its rated capacity. Normally expressed as a percentage.

**Overall Equipment Effectiveness** - a term initially coined in connection with Total Productive Maintenance (TPM). It provides a measure of overall asset productivity. Is
generally expressed as a percentage, and can be calculated by multiplying Availability by Utilization by Operational Efficiency by Quality Rate.

**Planned Maintenance** - any maintenance activity for which a pre-determined job procedure has been documented, for which all labor, materials, tools, and equipment required to carry out the task have been estimated, and their availability assured before commencement of the task.

**Plant Engineering** - a staff function whose prime responsibility is to ensure that maintenance techniques are effective, that equipment is designed and modified to improve maintainability, that ongoing maintenance technical problems are investigated, and appropriate corrective and improvement actions are taken. Used interchangeably with Maintenance Engineering and Reliability Engineering.

**Predictive Maintenance (PdM)** - an equipment maintenance strategy based on measuring the condition of equipment in order to assess whether it will fail during some future period, and then taking appropriate action to avoid the consequences of that failure. The condition of equipment could be monitored using Condition Monitoring, Statistical Process Control techniques, monitoring equipment performance, or through the use of the Human Senses. The terms Condition Based Maintenance (CBM), On-Condition Maintenance and Predictive Maintenance can be used interchangeably.

**Preventive Maintenance (PM)** - an equipment maintenance strategy based on replacing, overhauling or remanufacturing an item of an asset at a fixed interval, regardless of its condition at the time.

**Purchase Requisition** - The prime document issued by the user departments to the Purchase department authorizing the purchase of specific materials, parts, supplies, equipment or services from external suppliers.

**Purchase Order** - The prime document issued by an organization to an external supplier, ordering specific materials, parts, supplies, equipment or services.
Reliability - the capability of an asset to continue to perform its intended functions. Normally measured by Mean Time Between Failures (MTBF).

Reliability Centered Maintenance (RCM) - A structured process, originally developed in the airline industry, but now commonly used in many industries to determine the equipment maintenance strategies required for any physical asset to ensure that it continues to fulfill its intended functions in its present operating context.

Reliability Engineering - a staff function whose prime responsibility is to ensure that maintenance techniques are effective, that equipment is designed and modified to improve maintainability, that ongoing maintenance technical problems are investigated, and appropriate corrective and improvement actions are taken. Used interchangeably with Plant Engineering and Maintenance Engineering.

Run-to-Failure – Also called to Breakdown Maintenance or Corrective Maintenance. An Equipment Maintenance Strategy, where no routine maintenance tasks are performed on the equipment. The only maintenance performed on the equipment is after the equipment has suffered a failure.

Safety Consequences - a failure has safety consequences if it causes a loss of function or other damage that could hurt or kill someone.

Schedule Compliance - one of the Key Performance Indicators (KPI) often used to monitor and control maintenance. It is defined as the number of Scheduled Work Orders completed in a given time period (normally one week), divided by the total number of Scheduled Work Orders that should have been completed during that period, according to the approved Maintenance Schedule for that period. It is normally expressed as a percentage, and will always be less than or equal to 100%. The closer to 100%, better the performance for that time period.

Scheduled Maintenance - any maintenance work that has been planned and included on an approved Maintenance Schedule.
**Shutdown Maintenance** - Maintenance that can only be performed while equipment is shutdown

**Stores Requisition** - The prime document issued by the user departments authorizing the issue of specific materials, parts, supplies or equipment from the store or warehouse.

**Total Asset Management** - an integrated approach to Asset Management which incorporates elements such as Reliability Centered Maintenance, Total Productive Maintenance, Design for Maintainability, Design for Reliability, Value Engineering, Life Cycle Costing, Probabilistic Risk Assessment and others, to arrive at the optimum Cost-Benefit-Risk asset solution to meet any given production requirements.

**Total Productive Maintenance (TPM)** - a company-wide equipment management program with its origins in Japan, emphasizing production operator involvement in equipment maintenance, & continuous improvement approaches.

**Utilization** - the proportion of available time that an item of equipment is operating. Calculated by dividing equipment operating hours by equipment available hours. Generally expressed as a percentage

**Work Order** - The prime document used by the maintenance function to manage maintenance tasks. It may include such information as a description of the work required, the task priority, the job procedure to be followed, the parts, materials, tools and equipment required to complete the job, the labor hours, costs and materials consumed in completing the task, as well as key information on failure causes, what work was performed etc.

**Work Request** - The prime document issued by production departments requesting the initiation of a maintenance task for a particular equipment or asset. This is usually converted to a work order after the work request has been authorized for completion.
APPENDIX D

Examples of Different Module Screens in CMMS

These are some examples of the “Work Request Screens” that are currently available in the CMMS systems.

Work Request Screen  (Source: Champs CMMS)
Work Request Screen  (Source: MainPlan CMMS)

Work Request Screen  (Source: ExpressMaintenance CMMS)
Source: Smart Maintenance CMMS (Work Request Screen)

Source: Ivara CMMS (Work Request Screen)
These are some examples of the Work Order Screens currently available in the CMMS systems.

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<th>General</th>
<th>Additional</th>
<th>Associated Steps</th>
<th>Completion</th>
<th>Cost</th>
<th>Permits</th>
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</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>Requestor: Gay</td>
<td>Permit to Work Required?</td>
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<td></td>
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</tr>
<tr>
<td>Description: REPLACE PUMP SEAL AT DISCHARGE FLANGE</td>
<td></td>
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</tbody>
</table>

Asset Class: Mechanical Equipment | Asset Id: PMP-002 | | | | |
Asset Type: Pump | Problem Found: Leak | | | | |
Asset Name: BACKUP PUMP FOR MAIN WATER SUPPLY LINE 1 | | | | | |
Location: | | | | | |
Required Resolution: 00:00/0000 00:00:00 AM | Resource Sched. Date: 00:00/0000 00:00:00 AM | | | | |
Down Time Start: 00:00/0000 00:00:00 AM | Down Time End: 00:00/0000 00:00:00 AM | | | | |
Discontinued? | | | | | |

Source: Champs CMMS (work order module)
Source: MaintiMizer CMMS (Work Order Screen)

Source: TMA Systems CMMS (Work Order Screen)
Source: BenchMate CMMS (Work Order Screen)
These are some examples of the “Equipment Module Screens” that are currently available in the CMMS systems.

Source: ExpressMaintenance CMMS (Equipment Module)
Source: MaintiMizer CMMS (Equipment Module)

Source: BenchMate CMMS (Equipment Module)
Source: SmartMaintenance CMMS (Equipment Module)
These are some examples of the “Personnel Module Screens” that are currently available in the CMMS systems.

Source: Chase CMMS
These are some examples of the “Inventory Module Screens” that are currently available in the CMMS systems.

Source: Maintenance Coordinator
Source: Chase CMMS
These are some examples of the “Purchasing Module Screens” that are currently available in the CMMS systems.

Source: Maintenance Coordinator
Source: ProTeus CMMS

Source: MaintiMizer CMMS
This is an example of the “Preventive Maintenance Module Screens” that is currently available in the CMMS systems.

<table>
<thead>
<tr>
<th>Machine</th>
<th>Average Hours</th>
<th>Total Hours</th>
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<tr>
<td>001 Yeast Refrigeration Compressor #1</td>
<td>3</td>
<td>2.66</td>
</tr>
<tr>
<td>001 Yeast Refrigeration Compressor #2</td>
<td>4</td>
<td>6.62</td>
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<tr>
<td>002 Bulk Flour Bin #1</td>
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<td>12.93</td>
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<td>002 Bulk Flour Bin #2</td>
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<td>002 Bulk Flour Bin #3</td>
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<td>3.63</td>
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<td>107 Troug Hose #6</td>
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<td>7.00</td>
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<td>206 Rounde #1</td>
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<td>211 Proof Box #1</td>
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<td>70</td>
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<tr>
<td>404 Bagger #1</td>
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<td>15.00</td>
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Source: MaintSmart CMMS
BIBLIOGRAPHY


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