Implementation of the Computerized Maintenance Management Systems (CMMS) for the Maritime Industry

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***Abstract*— The management of marine fleet is a critical challenge that directly affects success of the overall company. The ship has to comply with the safety and pollution prevention regulations issued by the Flag State, the Port State Authorities and the IMO. In operation, the ship must be periodically surveyed for maintenance of class and the class certificate. Additionally, as required by the ISM code, the maintenance management of the ship is the primary responsibilities of the ship owner and ship management company. The Computerized Maintenance Management System (CMMS) is always used in preventive maintenance (PM) as analysis and planning functions, if the CMMS can be recognized by Classification Societies, it will be used as an approved system for obtaining PMS notation.**

***Index Terms* - CMMS, Maintenance management, Maritime Industry**

I. INFORMATION BASE FOR MAINTENANCE MANAGEMENT

Maintenance [I] is an effort to ensure that the assets of a company continue to provide a service, which will then ensure that the company can provide its designated service. During the later half of the 20th century, the general business climate began to change, the business strategies were changed also to adapt with that competition environment. As result, the maintenance practices have received some attention in the process, they were moving from the common **corrective maintenance** (CM) [II] to the planned **preventive maintenance** (PM) [III] and then the condition-based **predictive maintenance** (PDM) [IV].

The PM takes on a new meaning when using a reliability-based strategy. Its function establishes machinery histories, performances cost analysis, uses these machinery histories and cost to perform Pareto analysis to determine where resources should be allocated for maximize reliability. The PM performs maintenance planning, assuring coordination with other functions, assuring that spare-parts and tools are available, and uses histories are routinely reviewed to minimize stores, yet maximize the probability of assuring equipment uptime. [1]

The early PM programs were frequently implemented on manual, card-based systems. Things have changed with the introduction and advancement of computers and information technology (IT). The initial IT were typically manual, focused on bookkeeping and then IT began to be highly automated, which made it more practical to model the business in much more complex way. The PM clearly took off the established IT as a conjunction with the **Computerized Maintenance Management Systems** (CMMS) that can be integrated almost of four authority structures: business data processing, telecommunications, specialized office products and general office products. [2]

II. CMMS AND MARINE FLEET MANAGEMENT

2.1 In transportation, an equipment maintenance-repair-operation (MRO) is a mission-critical activity

Specializing in the maritime industry, an out-of-service of marine vessel can increase operating costs, damage customer relations, create unsafe operating environments, and, of course, decrease profits.

A ship has to comply with the safety and pollution prevention regulations [V] issued by the Maritime Authority of the country whose flag the ship is flying (Flag State), the Port State Authorities, and the conventions of the International Maritime Organization (IMO). In operation, the ship must be periodically surveyed for maintenance of class and the class certificate.

As required by the International Standard of Management (ISM) Code, the ship owner and ship management company should ensure that the ship hull structures, machinery and equipment are maintained and operated

- The ship maintenance should be in conformity with the applicable rules, regulations, requirements, procedures and standards established by the company.

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- The ship maintenance procedures should be implemented ashore and on board properly.

As required by ISM Code, the ship maintenance procedures should be documented, and should ensure that applicable statutory, class, international (e.g. SOLAS, MARPOL) and the port state requirements are met, and that compliance is maintained in the intervals between third-party surveys and audits.

The company should also take into account the following when developing and improving maintenance procedures: -

- The maintenance recommendations and specifications of the equipment manufacturer
- The history of the equipment, including failures, defects and damage, and the corresponding remedial action
- The results of third-party inspections
- The age of the ship
- The identified critical equipment or systems
- The consequences of the failure of the equipment on the safe operation of the ship. [3]

2.2. Planned Maintenance System (PMS) applied for the Class approval

The ship owner/manager can make a formal request to class for system/type approval. The system approval is valid for all ships managed by the ship owner/manager, having this PMS [VI] implemented on board. The 2nd step is the implementation survey on the PMS on board as basis for granting this survey arrangement to each ship. The 3rd step is the PMS final vessel approval, upon confirmation from the attending surveyor that a successful implementation survey has been carried out. [4]

Refer to the details in Machinery Surveys ([5] Table E1) the PMS should cover the items and systems as:

- Propulsion machinery
- Gear
- Auxiliary machinery
- Pumps
- Pipes, valves, independent tanks etc. inside machinery spaces
- Electrical installations
- Sundry

A systematic approach to the PMS will include:

- Establishing maintenance intervals
- Defining inspection methods & frequency
- Specifying inspection type, measuring equipment and required accuracy
- Establishing appropriate acceptance criteria
- Assigning responsibility for inspection activities to appropriately qualified personnel
- Assigning responsibility for maintenance activities to appropriately qualified personnel
- Defining requirements and mechanisms for reporting

ISM Code (10.1) states:

"The Company should establish procedures to ensure that the ship is maintained in conformity with the provisions of the relevant rules and regulations and with any additional requirements which may be established by the Company"

The PMS is to include documentation of:

- Inventory Content
- Maintenance Time Intervals
- Maintenance Instructions
- Maintenance Documentation & History
- Routine for "Handling of Postponed Jobs"
- Reference Documentation
- Electrical Equipment
- Instrumentation / Automation Equipment
- Condition Monitoring (if applicable)
- Routine for reporting and use of maintenance history data for continuous improvement of the PMS
- Description of the maintenance policy by the ship owner/manager
- Organizational flow-chart.

III. TYPICAL CMMS FOR MARITIME INDUSTRY

The softwares were installed at PTSC Marine Company and VSP-Maritime & Diving Division are the examples of the typical CMMS for maritime industry.

The software consists of 5 menus:

- Facilities Management
- Product Engineering Management
- Job Management
- Spare-part Management
- Reports

This version can be upgraded and integrated to

- Additional menus (workforce, cost, purchase, and supervisory management)
- Link to Enterprise Resources Planning (ERP)
- Integrate to Predictive Maintenance (PDM) special trend analysis systems.
- Assess to Distributed Control System (DCS)
- Contribute to AssetCare total solution

All equipment to be maintained is entered in the Facilities Management.

- Among the information entered are: entity, purchase, status, and registration of equipment. There are also areas for free-text additional information like technical information, photograph / drawing attached.
- It is important for the structure [VII] of the maintenance system that the inter-dependence of equipment is taken into account. The software gives the possibility to connect logically related equipment in a tree-structure, with equipment and sub-equipment in several levels.

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The software can handle an unlimited number of sub-equipment (levels).

Certain kinds of equipment are maintained on the ***basis of counters*** – hour, mileage or other kinds of counters. Upon selection, the counters should be read and entered with regular intervals. The software keeps track of the counter readings in order to calculate average use of the equipment per day, which is again used to calculate due date for jobs to be performed.

All documentation, drawing, photograph, spare-part catalogue, as well as maintenance routines / procedures what are related to equipment are entered in Product **Engineering Management**

- Document & drawing connected to equipment to be maintained cannot be changed. Any change must be approved and be given a new version number.
- Routine connected to the jobs, which have been performed, cannot be changed. Any change must be approved and be given a new version number. When this is done the Routine can be changed. When the job with connected

  Routines is to be performed, the latest version of the Routine is always used/printed

All jobs/work kept track by the software are entered in the **Job Management**.

- One or more Routines can be connected to a job-description. All Routines in the software has a unique coding, which is used to connect them to jobs. One Routine can be connected to several different jobs
- All Job Descriptions have a job type. This states what kind of job it is – e.g. Mechanical Maintenance, Repair, Inspection, etc.
- The user can freely define his/her own job types, whether they are periodical or not. When a periodical job is signed off as performed, the software will automatically calculate a new ***due date*** based on historical data.
- If a job does not have to be done exactly on the due date, the user may enter ***slack*** on this job. Slack gives a number of days from / to given due date, signifying that the job can be performed within this period.

  After a job has been performed, info about this must be entered into the software. To do ***sign-off performed jobs*** – using the **Job History** picture (when the user wants to or need to enter additional information about the job)

It is important that all preformed work is entered into the software, so the history becomes an important tool. The user can analyze this information to find out how the operation runs, what equipment is especially troublesome and what equipment often fails.

When jobs are signed off in the Job History picture, the following happens:

- A new due date is calculated
- The job is stored in the history table
- If the job is connected to Job Routines, these connections are copied to the job history with the version routine number

Equipment gradually deteriorates with use, and sooner or later the need for spare-parts arises. The **Spare-part Management** in the software is closely integrated with the **Job Management**.

- All equipment has the necessary spare-parts connected to it. All parts of equipment which may need repair or replacement are entered, and in some cases this will include all parts – the spare-parts connected to the equipment becomes the component list.
- Spare-parts have to be entered in the spare-part table before they can be connected to **Equipment** Description. The user enters spare-part's connection to equipment, its name, part number, catalogue reference number, delivery-input, storage info etc.
- The user can also enter substitute parts, i.e. parts can be used instead of this spare-part in case it is not available (in stock). The user can enter several possible vendors for each spare-part in free-text area at the lower part of Spare-part Description picture
- Spare-part use can be registered in the software. The stock will be reduced and a spare-part movement record is inserted in the movement table with number of parts used.

Paper printouts can be useful, and is an important part of the everyday use of the software.

- There are approximately 30 standard reports delivered with the software. The reports are sorted with reports for each sub-menu.
- The ***pre-defined reports*** in the software:
  - Facilities Listing
  - Document / Drawing Listing
  - Job Routine Listing
  - Job Planning Listing
  - Job History Listing
  - Spare-part Listing
  - Spare-part Use Listing
  - Spare-part in Stock Listing
- Upon request, the reports will be designed respectively.

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IV. Conclusion

The software contains powerful functions for accumulation of historical data about maintenance activities.

To present history information in other forms, interfaces between the software and other applications such as Lotus 123, Microsoft Excel are available. This gives the user the possibility to access database information directly from a spreadsheet. When the user later bring up a spreadsheet connected to the software, current information will be automatically fetched from the database. All the graphing capabilities of the spreadsheets can then be used on the maintenance data The software makes it easier to create new users, and to control their access to the different pictures in the software. The user is given the option to control each user's access to data. One user may be given access to update in some pictures and only look in other pictures, while another user can be denied update access altogether.

Although the software can meet the objectives of an CMMS, it is an effective tool to facilitate, simplify and rationalize administration of information and data about equipment, operation and maintenance. It is to help maintenance functions being more efficiency, to better use of maintenance staff, to coordinate inventory and works management, to manage tools & vendors, to capture costs & improve cost control in maintenance, and to communicate with the rest of company. Implementing a CMMS will not only demand an investment in software and computer equipment but also a substantial investment in training and date registration of equipment and its relevant documentation.

Notes

I As per the Oxford dictionary (Oxford University Press - 1995) maintain is to cause something to continue, to keep something in existence at the same level, standard. Maintain is also defined as to keep something in good condition or working order by checking or repairing it regularly

II Corrective Maintenance was defined by practices such as run-to-fail, breakdown / emergency maintenance, to some extent, it was also called as reactive maintenance.

III Preventive Maintenance was the time-based practices include: annual overhauls, quarterly calibration, monthly lubrication, etc.

IV Predictive Maintenance was the practices those were equipment condition based. Examples include changing a bearing long before it fails on vibration analysis, changing lubricant based on oil analysis showing excess wear particles, replacing steam traps based upon ultrasonic analysis, etc. In the best facilities, it also included review of process parameters as part of the condition-based approach.

V The following regulation certificates are relevant:

ILL *(International Load Line Cert.),*
CCC *(Cargo Ship Safety Construction Cert.),*
CSC *(Cargo Ship Safety Equipment Cert.),*
CRC *(Cargo Ship Safety Radio Cert.),*
PSC *(Passenger Ship Safety Cert.),*
IOPP *(International Oil Pollution Prevention Cert.),*
COF *(International Cert. of Fitness, Gas and Chemical Carriers),*
NLS *(International Pollution Prevention Cert. For the carriage of Noxious Liquid Substances in Bulk),*
COC *(Document of Compliance for ships carrying dangerous goods),*
DOC *(Document of Compliance for companies),*
SMC *(Safety Management Cert. for ships)*

VI To some extent, this PMS includes the time-based practices of the preventive maintenance (PM) and the predictive maintenance (PDM). It is accompanied with the continuous machinery surveys (CMS), the survey arrangement condition monitoring of rotating machinery (SACM), and the tail shaft monitoring system (TMON) to establish alternative survey arrangements for machinery and automation systems of DNV classification.

VII The structure is the means how you classify (group) your equipment and how you enter maintenance routines and procedures. The basic part of the software is the numbering system. There are several different numbering systems for classification of equipment, depending of what business you are. In addition to equipment numbering, it is also usual to use a tag number to identify equipment location.

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