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Maritime Management Systems

A survey of maritime management systems and utilisation of maintenance strategies

Master of Science Thesis

GÖSTA B. ALGELIN

Department of Shipping and Marine Technology
CHALMERS UNIVERSITY OF TECHNOLOGY
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Abstract

The aim with this research project was to survey the market for maritime management systems with focus on which maintenance management strategies that were utilised in a sample of the Swedish merchant fleet.

A sample of ten Swedish shipping companies or owning interests was selected that together represents 177 vessels on technical-, crew-, and safety management.

The selection of companies covered different segments of the shipping market with tank-, bulk, RoRo-, special service-, and passenger vessels. Interviews with the owners'/managers' technical management representatives have been performed. To support the survey documentary analyses covering sources from system suppliers, classification societies and reference industries have been performed.

The market for integrated maritime management systems in the surveyed fleet for maintenance and procurement management was covered by one major supplier with a 32 % market share and three with shares ranged between 16-22 %, the balance covered by separate and proprietary systems. Safety (ISM) management was covered by the integrated systems to 42 %, one major separate supplier to 26 % and the balance by minor and proprietary systems. Crew management was covered by one separate major supplier to 37 %, one to 17 % market share, a minor supplier and by proprietary systems. Ship/shore integration and VSAT satellite communication were implemented to a large extent. E-commerce and technical condition monitoring equipment were scarcely utilised.

The prevailing maintenance strategy was preventive planned maintenance. The machinery survey methods utilised were to 62 % the planned maintenance and continuous machinery survey methods. Only one owner/manager was planning to introduce strategies for condition monitoring (CM) and condition based maintenance (CBM). Despite that the benefits were known, there was amongst the owners/managers a resistance to implementation of CM technology, and thus CBM activities and consequently CM classification, based on

- Cost
- Bad experience
- Inconsistent data evaluation
- Equipment quality

The challenge to this is that the suppliers of CM systems and technology claim that the contemporary more developed condition monitoring systems and equipment have better quality, better trend and data analyses functionality and could be delivered at a more competitive price than previous generations of systems. Further that implementation of CM technology should be seen as an investment leading to, as indicated by the referenced industries, more reliable operation and thus cost and revenue benefits.

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Gösta Algelin

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1 Introduction

In the maritime industry a number of administrational management systems are used to provide information and to support decision making both onboard the vessels and ashore in the shipping companies´ offices.

Examples of the systems’ functionality are financial-, chartering and operations-, personnel-, safety-, quality-, document-, procurement-, and maintenance management.

In addition there are a number of technical management systems supporting various functions onboard such as navigation-, propulsion & manoeuvring-, machinery monitoring & control-, cargo handling-, and trim & stability systems.

The various administrational systems are often utilising distributed databases with a ship specific database onboard and a common database in the office, either system by system, or with integrated functionality of multiple systems with a common user interface. The information is replicated both ways ship/shore and the communication is often performed via satellite lines.

Despite that there has been some market consolidation amongst suppliers, the flora of systems and suppliers are ever increasing as well as the systems’ functionality of supported processes.

I have been working for many years in executive positions in a global market leading organisation delivering management and communication systems to the maritime and other industries, and I am the vice chairman in a branch organisation for maintenance management companies.

There are a number of interesting questions to focus on regarding this rather broad field of maritime suppliers and systems’ functionality, where comparisons towards shore based industries could be made how systems and functionality are utilised.

In a maritime research group meeting last year it was stated that cost efficiency in certain technical fields in the maritime sector is by decades lagging behind comparative fields in shore based industries. One example is how modern maintenance management techniques are utilised (Vinnova, 2009).

According the European strategic research agenda Waterborne one of the three pillars in the Vision 2020 is development of safe, sustainable and efficient sea transport and operation. A study that eventually could lead to implementation of improved maintenance management techniques in the maritime sector could be regarded as supporting development in this direction (Waterborne, 2007).

The objective with this thesis is to investigate how modern maintenance management techniques are utilised as a part of an overall asset management strategy in the maritime field.

One hypothesis is that implementation of improved maintenance management techniques in the maritime sector would lead to improved operation and cost benefits, something that could be covered in future studies.

Another hypothesis is that implementation of modern maintenance management techniques has room for improvement in the maritime sector. Two previous studies presented by separate classification societies show that despite availability of classification and maintenance management methods, systems and equipment for technical condition monitoring, these particular techniques are not to any larger extent implemented on board the societies' classed vessels.

About 2 % of one society's classed fleet (Holland, 2008) and less than 1 % of the other (Sanderlien & Bühring, 2008, p.22) had certified machinery condition monitoring survey arrangements implemented.

This thesis aims to reveal the background for decisions made regarding the implementation of modern maintenance management techniques. Is there a difference in various segments of the shipping market, type and age of ships or trading patterns?

One subject to be focused on is to which extent condition monitoring (CM) of technical equipment is utilised onboard and how that influences the amount of the preventive and other maintenance workload.

In this thesis a survey regarding the market for maritime management systems which are delivered as integrated packages with multiple functionalities and other separate systems will be presented. The survey focuses on which major system suppliers are operating in the market for ocean going merchant vessels owned or controlled by a sample of Swedish shipping companies or owning interests.

The survey covers which system and which functionality is utilised by the selected companies, both as integrated and separate management systems. Questions about existing ship/shore integration of the systems, communication methods, integration with other technical systems onboard and other administrative systems ashore have been raised.

The survey further focuses on the companies' current maintenance management strategies, such as by which classification society and the according which machinery maintenance arrangement the majority of the vessels in each owner's fleet are operated. Questions have also been raised which technical monitoring equipment is used onboard the vessels and about the companies' future plans for maintenance strategy development.

The Swedish merchant fleet, i.e. the fleet that is controlled by Swedish shipping companies or owning interests including Swedish and foreign flagged vessels, consists of about 600 vessels (Sjöfartens Bok, 2009).

The sample of companies has been selected out of companies that are members of the Swedish Shipowners Association. The survey covers ten ship owners/managers that have technical-, crew-, and safety management for 177 vessels. The management is performed either in house or through own subsidiary or external management companies, both Swedish and foreign. The ships are wholly or partly owned or chartered. In total the ten companies commercially control about 300 vessels.

The selection of companies has been made so the survey covers the spectrum from medium to large sized companies, i.e. companies commercially controlling from about 10 vessels to above 100 vessels.

The 177 vessels covered in the survey, i.e. vessels on technical-, crew-, and safety management by the selected companies, the managed fleets range from7 to 33 ships per company. The selection of companies covers segments of the shipping market with tank-, bulk-, RoRo-, special service-, and passenger vessels.

Further this thesis contains a documentary analysis regarding integrated maritime management systems and systems with separate functionality. Information has been collected from system suppliers' sources in order to describe the functionality of the systems and maintenance equipment.

The documentary analysis extends to investigate the classification societies' alternative machinery survey methods based upon utilisation of continuous, planned maintenance and condition monitoring regimes.

An additional subject is a thorough documentary analysis of each of the ten owner/manager's fleet included in the survey part. Information regarding each of the 177 vessels' individual class and machinery survey arrangements has been investigated and a summary will be presented. Information from the classification societies regarding each vessel's class status and machinery survey arrangements has been accessed from the societies' survey databases.

A foreign shipping company and a Swedish land based industry have further through documentary analysis been investigated regarding their maintenance management strategies for reference reasons.

2 Background

In today's competitive international shipping it is of utmost importance that the technical and administrative computer systems are of the highest standard, both on board the vessels and at the owners' and managers' offices. The systems are to be effective means to fulfil international organisations', flag states', classification societies' and charterers' requirements on reliable shipping operation (Algelin, 2007).

The requirements are defined in a number of rules and regulations. The control of that the requirements are met according internationally adopted conventions for maritime safety and environment protection regarding e.g. construction, ship building, maintenance and manning rests on the national shipping authorities (Sjöfartsverket, 2008).

The member states in the UN agency IMO, the International Maritime Organisation, have in recent years adopted a number of conventions and amendments to those regarding reliable shipping operation, maintenance, manning, protection against terrorism and environmental protection (IMO, 2010).

According statistics from UK Government Marine Investigation Branch 23% of all accidents with merchant vessels above 100 gross tons are due to machinery failure. The main causes for marine machinery failures are inspection or handling of equipment, insufficient maintenance, incorrect lubrication, poor machine installation and misalignment and balancing of rotating shafts (Galloway, 2008).

2.1 Rules & regulations

Examples of the rules and regulations influencing the shipping industry are the International Safety Management Code (ISM), the International Convention on Standards of Training Certification and Watch keeping for Seafarers (STCW), the International Ship and Port Facility Security Code (ISPS) and the International Convention for the Prevention of Pollution from Ships (MARPOL), (IMO, 2010).

The ISM Code Chapter 10 Maintenance of the ship and is equipment describes in general how ships should be maintained, inspected, non-conformities be reported and corrective actions be taken.

Paragraph 10.1 of the ISM Code states that 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.

In paragraph 10.3 of the ISM Code it states that the Company should identify equipment and technical systems that through sudden operational failure might result in hazardous situations (ISM, 2002).

When implementing a maintenance management system onboard a vessel as part of the shipping company's safety management system it is imperative to define the critical systems and equipment (IMO, 2002). Maintenance instructions according manufacturers and others instructions should be issued to ensure the uninterrupted and safe operation at all times (IACS, 2008).

In the design phase of a vessel some of the critical equipment and systems could be duplicated or even tripled in order to gain redundancy.

Such equipment requires specific maintenance management routines in their idle phase in order to function properly when taken in operation (IACS, 2008).

Shipping companies must strive for continuous improvement by monitoring safety and conducting internal audits to prevent recurrence of faults. Particular attention must be given to the human element in accidents and man/equipment interface (Mandaraka-Sheppard, 2007).

The classification societies develop according, and in addition, to the above rules detailed regulations for different types of ships and operation environments. The rules and regulations are continuously adjusted to new findings and new technology through additions to the class rules, e.g. continuous Survey for Hull and Machinery and Condition Based Maintenance (Bohmer, 2002).

The major classification societies are supporting routines for condition based maintenance where equipment and whole systems can receive a specific class certificate of alternative survey arrangement if maintained according this alternative method. The class notation grants simplified classification routines of the specific equipment and systems and thus lead to more flexible operation and reduced classification costs (Sanderlien & Bühring, 2008, p. 21).

The charterers also raise their specific requirements on operators and ships. In the tanker sector vetting inspections aboard are performed before a vessel for is accepted for charter.

The major oil companies have through their organisation The Oil Companies International Marine Forum (OCIMF), in addition to vetting inspections issued a system how to control that the tanker operators are adhering to OCIMF's specific requirements. The system is based upon the tanker operators' control of their own operation, summarised in Tanker Management Self Assessment (TMSA), where the outcome is compared with an agreed Best Practice standard (OCIMF, 2008).

2.2 Maritime Maintenance Management

The ISM Code stipulates that each ship operator is responsible for that safe and pollution free operation of the ship is ensured, and that the ship's hull, machinery and equipment is maintained and operated in accordance with applicable rules and regulations (ISM, 2002).

The senior management has to be committed to provide required resources, competent crew and a well designed and implemented maintenance management system in order to achieve these objectives onboard.

The fundamental part of the maintenance management system is a database that contains a register of all equipment onboard that need to be maintained.

In the databases various registers are kept and the following information should be recorded (IACS, 2008).

Maintenance intervals
Inspection intervals and methods
Inspection and measuring equipment to be utilised
Acceptance criteria
Personnel responsible for inspection and maintenance activities
Reporting requirements

Establishment of maintenance intervals should be according:

Manufacturers' recommendations and specifications
Condition based maintenance management techniques
Practical experience
The current operational mode of the equipment
Certain operational requirements
Class or other administration or company requirement
Testing of redundant equipment

Establishment of inspection intervals should be based according to acceptance criteria and the measuring and testing equipment's calibration and accuracy. Checklists according manufacturers' recommendations should be developed.

The following types of inspections and test may be applicable;

Visual inspection
Vibration tests
Pressure tests

Temperature measurements
Electrical tests
Load tests
Water tightness inspections

Different methods and strategies are available when developing maintenance management routines for equipment and systems for a particular vessel or fleet of vessels.

An analysis of the equipment and systems criticality should be performed (Andersson, 2008).

FMEA

IMO's Formal Safety Assessment (FSA), is the fundamental guideline for maritime risk management (IMO, 2002).

It consists of five steps: identification of hazards, assessment of risks, risk control options, a cost/benefit assessment to determine the cost effectiveness of each risk control option and, finally, recommendations for decision-making – determining which risk control options should be selected. Application of FSA will be particularly relevant to proposals for regulatory measures that may have far-reaching implications in terms of costs to the maritime industry or the administrative or legislative burdens that may result (O´Neil, 2000).

The human element is one of the most important contributory aspects to the causation and avoidance of accidents. Human element issues throughout the integrated system should be systematically treated within the FSA framework, associating them directly with the occurrence of accidents, underlying causes or influences. Appropriate techniques for incorporating human factors should be used (IMO, 2002).

All risk management methods and techniques are eventually aiming at controlling and minimising risks. During the assessment process certain risk levels for potential hazards are established such as negligible, tolerable and intolerable. Efforts have to be made to move all identified intolerable hazards from the intolerable region down to the tolerable region, or the As Low As Reasonably Practicable (ALARP) level. The economical aspects have to be considered when defining which efforts that are reasonable to make in order to move hazards down into the ALARP region. Quite considerable costs might have to be accepted depending on the project and circumstances (Kou, 2008).

There are various methods to be utilised in risk analysis and risk assessment, mainly divided in quantitative and qualitative methods. The quantitative methods can be based upon abstract models, either deterministic or stochastic. The stochastic approach relies often on probabilistic models using statistical data (Montgomery & Runger, 1999).

The qualitative methods are based upon evaluation of empirical data by experienced personnel according different models such as Hazard Operability (HazOp) and Failure Mode and Effect Analysis (FMEA), (IMO, 2002).

When identifying equipment and technical systems that through sudden operational failure might result in hazardous situations the Failure Mode and Effect Analysis (FMEA) methodology can be applied (IMO, 2002).

FMEA is a formalised, standardised and systematised process/method for analyses of potential failure modes within a system and their probability of occurrence. Failure modes are any errors or defects in a process, design or item and can be potential or actual. Effects analysis refers to studying the consequences of those failures (Dailey, 2004).

The FMEA methodology relies on some prerequisites that are utilised in general quality and safety management. The top management have to be fully committed to the process, a quality management system have to exist and well trained continuous improvement teams under dedicated leadership have to be established (Dailey, 2004).

The basic concepts of FMEA is mapping of the processes to be analysed, brainstorming of possible failures and effects, root cause analysis of occurred events considering the Pareto rule and continuous improvement according the Kaizen philosophy (Dailey, 2004).

The Pareto, or the 80/20, rule states that 80 % of the effects are a result of 20 % of the causes (Montgomery & Runger, 1999).

The Kaizen philosophy is a concept that through continuous improvements of processes and people’s activities will be fundamental in reaching the outlined main management objectives (Imai, 1986).

It is a philosophy that focuses on continuous improvement in all aspects of life, and when applied to the working environment Kaizen aims at improving all functions and processes of a company, regardless of an employee’s position, or the apparent importance of a particular activity (Kaizen, 2000).

Kaizen is a concept that, when implemented correctly, through elimination of excessive work load makes the workplace more humane, and it teach people how to improve their work situation through scientific experiments (Kaizen, 2000).

For Kaizen to be effective there has to be a culture of trust between staff and managers, supported by a democratic structure (Kaizen, 2000).

Kaizen can operate at the level of an individual, or through Kaizen Groups of improvement or Quality Circles, which are groups specifically gathered to identify potential improvements. The Quality circles operates according the iterative PDCA principle: Plan-Do-Check-Act (Kaizen, 2000).

Improvements that are based on many, small changes rather than the radical changes that might arise from research and development are less likely to require major capital investment than major process changes. As the ideas come from the employees, they are less likely to be radically different, and thus easier to implement (Imai, 1986).

Risk can be defined as the combination of the probability of the occurrence of an event and its consequences (ISO, 2002).

In project management risk is defined as an uncertain event that, if it occurs, has a positive or negative effect on the project objective (PMBOK, 2004).

According to the general definition of risk (ISO, 2002) the FMEA use the same concepts regarding the probability that a failure cause will occur and the severity of failure consequences. An additional risk concept is the possibility that the cause of the failure, or the failure mode itself, will pass through a screening program undetected (Dailey, 2004).

In the evaluation process the reasons for a failure, the means by which the failure appears and the impact of the failure has to be analysed (Dailey, 2004). When applying FMEA a small team of personnel that is familiar with the systems and equipment should be established. They have a meeting led by a moderator where they could use brainstorming or Delphi techniques, which is a more sophisticated method for structuring a group communication process so that the process is effective in allowing a group of individuals as a whole to deal with a complex problem. Questions raised are replied to in more than one round. After each round the moderator makes an anonymous summary of the replies and judgments. In the next round the individual replies are likely to be different based upon the replies of other team members, thus striving for consensus about the topic (Linstone & Murray, 1975).

A defined target with which issues should be tackled within a specific time frame should be defined. The outcome of the meeting should be documented. Process mapping requires that the members of the team are familiar with the processes, have equipment knowledge and that the processes are operable. The mapping consists of identifying, classifying and sequencing the processes and tasks necessary to accomplish a given process. The processes should be graphically presented in a flow chart (Dailey, 2004).

The FMEA draws up a comprehensive list of all potential failure modes and their potential effects and is used to rank the risks associated with the failure modes. The highest ranked items are prioritised and acted upon and then they are re-evaluated in a continuous loop until the effects are acceptable (Dailey, 2004).

In the root cause evaluation process the real reasons for a failure has to be established. The 5 Why methodology can be utilised, i.e. the question ‘why’ should be asked repeatedly since the first answer often is wrong, since it many times suggests that a corrective action should be performed by somebody else or in another place. Applied corrective actions have no effect if the root cause not is found (Dailey, 2004). The Pareto rule is often applicable, i.e. 80 % of the effects are a result of 20 % of the causes (Montgomery & Runger, 1999).

Corrective Maintenance

The traditional way to perform maintenance activities is to repair an object when it has broken down either by accident or as an expected event.

Corrective maintenance is defined as activities undertaken to detect, isolate, and rectify a fault so that the failed equipment, machine, or system can be restored to its required function (Stoneham, 1998).

Run to failure

Run to failure can be used as a maintenance management methodology i.e. no repairs are undertaken until an object actually breaks. “If it’s OK, don’t fix it” (Stoneham, 1998).

A synonymous description is *Run to break down*.

Run to destruction

Run to destruction is an alternative method meaning that the object is completely replaced when broken down (Stoneham, 1998).

Examples on board where either of these two methods could be applicable are for redundant circulation pump functions, e.g. in a fresh water system.

Often the three concepts *Run to failure*, *Run to break down* and *Run to destruction* are used interchangeably without the distinction if it is a repair or complete replacement to be performed.

Planned/Preventive Maintenance

Planned/preventive maintenance can be defined as systematic inspection, detection, correction and prevention of failures before they become actual or major failures.

Planned/preventive maintenance is always time based either by calendar or by the objects actual run-time. The maintenance intervals are mainly based on empirical data of the mean time between failures (MTBF), (Mobley, 1990).

Examples on board where Planned/Preventive maintenance activities are utilised are for propulsion and auxiliary engines.

Condition Based Maintenance (CBM)

CBM is carried out according to the need indicated by Condition Monitoring (CM).

CM is defined as continuous or periodic measurement and interpretation of data to indicate the condition determine the need for maintenance. The monitoring is carried out when the object is in operation (Stoneham, 1998).

An example on board where CBM activities are carried out is a rotating shaft in a turbo charger where e.g. CM according vibration monitoring indicates that there is a need for replacement of a bearing.

Opportunistic Maintenance

Opportunistic maintenance is carried out for an object when the opportunity is given, often in connection with unplanned activities for other objects in a system when the system is out of operation (Stoneham, 1998). It could also be performed in connection with planned activities for other objects (Almgren, Andréasson, Anevski, Patriksson, Strömberg & Svensson, 2008).

An example on board is when overhauling a purifier, all wear and tear parts are replaced, despite their actual status at the time for the scheduled overhaul of the main parts.

Reliability Centred Maintenance, RCM

Reliability Centred Maintenance (RCM) is a methodology where the maintenance activities are planned according a qualitative risk based method in order to find the optimal balance between preventive, condition based or periodic, and corrective maintenance.

When assessing the maintenance strategy for assets that are part of a technical system their functions and associated performance standards are evaluated (Moubray, 1997).

The assets are categorised in primary and secondary functions and their maintenance activities are structured accordingly.

Malfunctions are categorised in four categories depending on their consequences.

Hidden failure consequences
Safety and environmental consequences
Operational consequences
Non-operational consequences

The secondary functions and the non-operational consequences are treated with a less stringent maintenance methodology; some equipment can be classified as Run-to-failure instead of being maintained (Moubray, 1997).

2.3 Classification

The classification societies offer machinery classification services according traditional five years periodical machinery renewal surveys where a class surveyor controls that the equipment is in good working condition. During the five years annual, as well as a two and a half year intermediary, surveys are carried out (Sanderlien & Bühring, 2008).

The societies also offer alternative survey arrangements in connection with maintenance management of machinery components, summarised in continuous, planned and condition monitoring methods (Holland, 2008).

The continuous machinery survey method allows a certified chief engineer to carry out the surveys on board during the five year period according certain rules and with limitations for certain equipment (DNV, 2008).

The planned maintenance system method requires that a computerised maintenance system is utilised in addition to the continuous machinery scheme. Surveys are carried out by chief engineer in connection with major overhauls and the class surveyor make annual audits of the maintenance system's records (DNV, 2008).

The condition monitoring method requires in addition to a planned maintenance system condition monitoring equipment, procedures, schedules and methods for data collection and analysis. The machinery equipment is surveyed by the chief engineer in connection with overhauls that are carried out when the condition monitoring system indicates that it is required (DNV, 2008).

2.4 System development

The owners and management companies rely to a greater extent on computer systems to administer the compliance of the above rules and regulations, and to make their business processes more effective.

The contemporary maintenance systems have through the years developed from being traditional maintenance & procurement systems to become comprehensive systems handling almost all technical and administrative routines on board, where all functions have been gathered in one database and handled through one common user interface.

The development of maritime management systems follow the general development trend of information technology (IT) systems where the systems' functionality increase and is further integrated into enterprise resource planning (ERP) systems (Kans, 2008).

The systems utilises common functions for ship/shore data transfer and are often integrated with the e-mail systems, so that all data continuously is kept updated both on board and at the operators' offices.

The contemporary systems contain functionality to comply with the requirements on planned maintenance in the Safety Management System (SMS), with non-conformity reporting and document control according the ISM code.

The personnel systems are used for follow up of the crew's education, training and certification according the STCW convention. Other personnel information and information from the system's procurement function regarding e.g. spare parts deliveries can be used in connection with reporting according the ISPS code.

Today the systems are integrated with condition monitoring equipment in order to be compliant with classification societies CBM-class requirements, and can also be integrated with the operators' financial systems to get direct access to procurement and budget information for financial follow-up. For the tanker sector systems functionality cover self assessment according the TMSA program (Algelin, 2007).

2.5 Delimitations

Despite the survey's and documentary analysis' coverage of a rather comprehensive part of the Swedish merchant fleet, the information presented does not have the ambition to be regarded as representative for all interests, suppliers, systems, technical solutions or prospective rationale for the decision making processes in the national shipping community.

2.6 Aim

The aim with this thesis can be summarised as to investigate how modern maintenance management methods and techniques are utilised as a part of an overall asset management strategy in the maritime field, and to reveal the background for decisions made regarding the implementation of modern maintenance management techniques on board.

To support that aim a survey of the market for integrated and separate maritime management systems as well as an estimate of the suppliers' market share of installed systems in offices and fleets amongst a sample of shipping companies will be presented.

3 Methodology

3.1 Design

The research in this thesis is mainly based upon the hermeneutic design tradition where the utilised interview survey method with flexible design has generated qualitative data.

Survey

To cover the scope of the research questions a semi-structured interview methodology was developed where the fundamentals of the interviews were configured around ten main questions with a couple of follow up questions depending on the respondents' replies.

Documentary analysis

One of the scopes with the development of the documentary analysis was to cover sources from system suppliers in order to describe the functionality of integrated maritime management systems as well as of systems and equipment with separate functionality. The documentary analysis was performed according the respondents' replies in the interview survey regarding systems and equipment used by their companies.

The second scope was to cover information from classification societies regarding maintenance management, alternative survey methods and the respective machinery survey arrangement for utilisation of continuous, planned maintenance and condition monitoring regimes.

The third scope with the development of the documentary analysis was to cover information from the respective classification society for each individual vessel in each fleet of the ten owners/managers according the respondents replies in the survey part.

An additional documentary analysis task was for reference reasons to the main survey part to investigate a foreign shipping company and a Swedish land based industry regarding their maintenance management strategies.

3.2 Participants

A sample of Swedish shipping companies or owning interests that represents merchant vessels mainly in foreign trade was selected. The survey covers ten ship owners/managers that have technical-, crew-, and safety management for 177 ships. These 10 companies commercially control about 300 vessels.

The selection of companies was made so that the survey covers the spectrum from medium to large sized companies, i.e. from companies commercially controlling about 10 vessels to above 100 vessels. In the total of the 177 vessels covered by technical-, crew-, and safety management owned by Swedish interests the range is from 7 to 33 ships.

The selection of companies covers different segments of the shipping market with tank-, bulk, RoRo-, special-, and passenger vessels. In total the survey comprises 71 tankers, 60 RoRo-, 18 Pax/RoPax-, 20 bulk/dry cargo-, and 8 special service ships in the 10 fleets covered.

The research questions have been addressed to ship owners' and operators' technical management representatives. One representative from each company's technical management team has been interviewed. All respondents are male and have long experience in their professions.

The respondents in the survey and their companies were granted anonymity. Information about which suppliers of management systems the companies are utilising will also be presented anonymous. A code numbering system will be used for the systems and companies presented.

3.3 Procedure

Survey

The selected respondents in each company were contacted to book a time for an interview. They were informed about the background and scope of the interview. They were further informed that it should be performed by telephone in an estimated time of half an hour to forty minutes, and that the interviews were to be recorded. The interviews were to be done in Swedish and later translated into English.

All ten respondents gave informed consent to be interviewed.

The research questions configured around ten main questions with a couple of follow up questions depending on the respondents' replies were asked through semi-structured interviews with each of the respondents. The interviews were performed by telephone and took in average about thirty minutes. Each interview was recorded and saved on media. The recordings were later replayed and a summarised transcription was made for each interview.

Questions about which system and which functionality is utilised by their companies, both as integrated and separate management systems were asked. Questions about existing ship/shore integration of the systems, communication methods, integration with other technical systems onboard and other administrative systems ashore were raised.

Questions about their companies' current maintenance management strategies, such as by which classification society and the according which machinery maintenance arrangement the majority of the vessels in each owner's fleet are operated were asked. Questions were also raised about which technical monitoring equipment is used onboard the vessels and about the companies' future plans for maintenance strategy development.

Documentary analysis

The first part of the documentary analysis covers sources from system suppliers in order to describe the functionality of integrated maritime management systems. Systems with separate functionality and available common systems and equipment for technical condition monitoring are also covered. The analysis is based upon the suppliers' documentation regarding their system's and equipment's functionality. The suppliers' full identity will not be revealed in this survey. The documentary analysis was performed according the respondents' replies in the interview survey of which systems their companies were utilising. Information has been collected from fourteen suppliers.

The second part covers information from classification societies regarding maintenance management, alternative survey methods and the respective machinery survey arrangement for utilisation of continuous, planned maintenance and condition monitoring regimes.

Regarding the classification societies the documentary analysis is based upon their documentation regarding classification rules and regulations as well as maintenance management recommendations. Information from one of the societies only is presented since all of the covered societies have similar regimes for machinery survey arrangements.

The third part of the documentary analysis covers information from the respective classification society for each individual vessel in each fleet of the ten owners/managers. The analysis has been performed according the respondents replies in the survey part, of which vessels their companies had technical-, crew-, and safety management for, in total 177 vessels.

Information from the classification societies regarding each vessel's class status has been accessed from the societies' survey databases.

The following classification societies' survey databases have been investigated:

American Bureau of Shipping, ABS	Eagle Operate
Bureau Veritas, BV	VeriSTAR
Det Norske Veritas, DNV	DNV Exchange
Germanischer Lloyd, GL	Fleet online
Lloyds Register, LR	ClassDirect
Nippon Kaiji Kyokai, NKK	Class NK

The additional reference documentary analysis task regarding a foreign shipping company and a Swedish land based industry has been performed through analysis of relevant papers presented at conferences.

4 Result

4.1 Survey and documentary analysis

The ten survey questions including follow up questions are presented in an appendix (see Appendix 29, Questionnaire).

A brief summary of each owner's/manager's fleet and the respondents' replies to the survey questions, system categories etc. are presented in an annex (see Survey results at page 95 of this thesis).

The full functionality of each standard system according the suppliers' information is presented in appendices (see Appendices 1 to 15). No full functionality for the proprietary or accounting systems used by the owners/managers will be presented in this report.

4.2 Owners/Managers

Owner/Manager no. 1

Owner/Manager no. 1 had a fleet of 12 vessels, mainly short sea bulkers, on technical and other management.

The respondents' replies to the survey questions, an introduction to the integrated and separate management systems' functionality utilised by each Owner/Manager and a description of their fleet, classification and survey methods are presented in an appendix (see Appendix 17, Owner/Manager no. 1).

Owner/Manager no. 2

Owner/Manager no. 2 had a fleet of 30 vessels, mainly RoRo ships and special tonnage, on technical and other management.

The respondents' replies to the survey questions, an introduction to the integrated and separate management systems' functionality utilised by each Owner/Manager and a description of their fleet, classification and survey methods are presented in an appendix (see Appendix 18, Owner/Manager no. 2).

Owner/Manager no. 3

Owner/Manager no. 3 had a fleet of 30 tankers on technical and other management.
The respondents' replies to the survey questions, an introduction to the integrated and separate management systems' functionality utilised by each Owner/Manager and a

description of their fleet, classification and survey methods are presented in an appendix (see Appendix 19, Owner/Manager no. 3).

Owner/Manager no. 4

Owner/Manager no. 4 had a fleet of 16 Pax/RoPax vessels on technical and other management.

The respondents' replies to the survey questions, an introduction to the integrated and separate management systems' functionality utilised by each Owner/Manager and a description of their fleet, classification and survey methods are presented in an appendix (see Appendix 20, Owner/Manager no. 4).

Owner/Manager no. 5

Owner/Manager no. 5 had a fleet of 18 tankers on technical and other management.

The respondents' replies to the survey questions, an introduction to the integrated and separate management systems' functionality utilised by each Owner/Manager and a description of their fleet, classification and survey methods are presented in an appendix (see Appendix 21, Owner/Manager no. 5).

Owner/Manager no. 6

Owner/Manager no. 6 had a fleet of 11 vessels, mainly short sea bulkers, on technical and other management.

The respondents' replies to the survey questions, an introduction to the integrated and separate management systems' functionality utilised by each Owner/Manager and a description of their fleet, classification and survey methods are presented in an appendix (see Appendix 22, Owner/Manager no. 6).

Owner/Manager no. 7

Owner/Manager no. 7 had a fleet of 10 tankers on technical and other management.

The respondents' replies to the survey questions, an introduction to the integrated and separate management systems' functionality utilised by each Owner/Manager and a description of their fleet, classification and survey methods are presented in an appendix (see Appendix 23, Owner/Manager no. 7).

Owner/Manager no. 8

Owner/Manager no. 8 had a fleet of 7 vessels, mainly Pax/RoPax, on technical and other management.

The respondents’ replies to the survey questions, an introduction to the integrated and separate management systems’ functionality utilised by each Owner/Manager and a description of their fleet, classification and survey methods are presented in an appendix (see Appendix 24, Owner/Manager no. 8).

Owner/Manager no. 9

Owner/Manager no. 9 had a fleet of 33 RoRo-ships on technical and other management.

The respondents’ replies to the survey questions, an introduction to the integrated and separate management systems’ functionality utilised by each Owner/Manager and a description of their fleet, classification and survey methods are presented in an appendix (see Appendix 25, Owner/Manager no. 9).

Owner/Manager no. 10

Owner/Manager no. 10 had a fleet of 10 tankers on technical and other management.

The respondents’ replies to the survey questions, an introduction to the integrated and separate management systems’ functionality utilised by each Owner/Manager and a description of their fleet, classification and survey methods are presented in an appendix (see Appendix 26, Owner/Manager no. 10).

4.3 System suppliers’ market share

The survey revealed that regarding maintenance and procurement management there were four suppliers of integrated maritime management systems with multiple functionalities active amongst the surveyed owners/managers. One supplier covered 32 %, one 22 %, one 17 % and one 16 % of the surveyed market. The balance was covered about equally by one separate standard system at 7 % and one proprietary system at 6 %.

There was one owner/manager utilising e-commerce functionality from one supplier.

ISM management was covered by the integrated systems with multiple functionalities together to 42 % of the surveyed market, by one standard system supplier to 26 % and the remaining balance by minor and proprietary systems.

Crew management was utilised in the surveyed market by separate system suppliers only, where one supplier covered 37 %, one 17 % and the remaining balance was covered by one minor supplier at 6 % and proprietary systems.

There was a restructuring process amongst three of the owners/mangers where the current systems were about to be changed to systems from other suppliers. This involved for two of the owners/managers systems with integrated functionality and for one of the owners/managers an ISM system.

Regarding technical condition monitoring equipment such as for vibration measurement there were three suppliers active in the covered market but with few then active installations on board the vessels.

4.4 Ship/shore integration

The information in all of the on board systems in the surveyed market was accessible by the owners'/managers' shore offices personnel. The technology differed between manual or semi-automatic file transfers via e-mail, fully automated replication between the ship/shore databases or on-line data access via VPN tunnels or web clients.

The information was carried by mobile telephony and wireless LAN when coverage was available, or by satellite communication such as by SatCom-, Inmarsat B-, and VSAT-suppliers.

70 % of the surveyed fleet was utilising VSAT communication.

4.5 Other integration

60 % of the office systems were integrated with accounting systems and as previously mentioned one owner/manager utilised integrated e-commerce functionality.

Regarding integration onboard with technical condition monitoring equipment such as vibration monitoring, none of the vessels in the surveyed market utilised such integration.

4.6 Maintenance management

Almost all owners/managers claimed that they were utilising a preventive planned maintenance strategy based on the machinery systems' and equipment's run-time and half of them in combination with gained experience. One respondent said that their company had a proactive approach and another that their company was introducing criticality analysis somewhat in line with RCM methodology.

4.7 Condition monitoring equipment

Five of the owners/managers representing 45 % of the surveyed fleet stated that they were using technical condition monitoring equipment, such as for vibration monitoring, but on few ships at few specific occasions, not on a regular basis.

The other five representing 55 % of the surveyed fleet of 177 vessels did not utilise any technical CM equipment on board their vessels.

4.8 Condition monitoring strategy

One of the owners/managers that represented 17 % of the surveyed fleet stated that there was a possible future strategy for implementation of more CM methods for new buildings.

One who represented 19 % of the surveyed fleet stated that criticality analysis of systems and equipment to be maintained were to be introduced and that CM might be a part of that strategy.

Four of the other owners/managers who represented 35 % of the surveyed fleet stated that they were open for new technology but had no outspoken CM strategy.

The rest of the respondents said that their companies did not have any strategy for implementation of CM equipment, systems, methods or introduction of machinery condition monitoring alternative survey methods.

Owner/Manager no. 1 with a fleet of 12 vessels, mainly short sea bulkers

According to the respondent;

The company was not utilising technical CM methodology since the ships were fairly small with only one man in the engine room. The reason for not using CM was the considerable investment for the implementation of technical CM.

There was currently no future strategy for implementation of more CM methods.

Owner/Manager no. 2 with a fleet of 30 vessels, mainly RoRo ships and special tonnage

According to the respondent;

The company was currently not utilising technical CM methodology to any larger extent since it was hard to implement these systems on old ships.

On board the newbuildings technical CM-systems for vibration monitoring etc. were to be installed. There was a possible future strategy for implementation of more CM methods in connection with deliveries of the new buildings.

The expected benefits were minimised maintenance costs, optimised operation, reduced costs and optimised classification routines.

Owner/Manager no. 3 with a fleet of 30 tankers

According to the respondent;

The company was not utilising technical CM methodology as a strategy. Measurements were taken on certain equipment when problems need to be temporarily monitored. There were some efforts to introduce CM equipment when specifying newbuildings. CM equipment was *also included in the engine manufacturers' deliveries of more sophisticated electronically controlled engines, such as modern engines equipped with common rail technology.*

The possible benefits with more CM were early warnings for break downs.

If it could be established that certain break downs were caused by lacking CM data, the process to implement CM equipment and systems would accelerate.

The main obstacles with CM technology were the costs involved for implementing the systems. Another cause was the crew's capability to evaluate the data correctly if there were too many different systems indicating operational malfunctions.

Owner/Manager no. 4 with a fleet of 16 Pax/RoPax vessels

According to the respondent;

The company was currently not utilising technical CM methodology to any larger extent. Some old CM equipment was used. CM was no longer included in the company's maintenance philosophy such as it was 10-15 years ago when it was used extensively.

CM has declined due to for shipping not properly adapted CM equipment, difficulties with easy presentation of the CM results and a common standard for evaluation of the data.

Another factor was the personnel intensity for the huge amount of data that need to be collected and evaluated. Purchasing third party CM evaluation consultancy was not an option.

There was no explicit CM strategy but the company was open to new technology when it had proven to be reliable.

Generally the benefits with condition based maintenance were that no maintenance activities were carried out in vain, and that the overhaul frequencies could be extended.

One of the obstacles to carry out CBM was that the company could have up to six persons to fulfil an engineer's position on board. Data analyses carried out by so many people would cause varied results.

Measurements and analyses could be carried out by designated teams for the whole company, but since the vessels were equipped with redundant technical systems, the benefits had not verified the costs. Imminent break downs had to be detected often in order to justify the investments and administration.

Owner/Manager no. 5 with a fleet of 18 tankers

No general utilisation of CM equipment, but vibration monitoring could be utilised as test and evaluation installations, e.g. on board one vessel that currently had problems with a shaft generator. The systems were not integrated. Data evaluation was performed by the supplier who had delivered the monitoring equipment.

There was no overall CM strategy in the company but if CM would be introduced it would lead to lower overall maintenance costs.

One of the obstacles for introduction of more CM methods could be that shipping was a conservative business. Another factor was that even if CM would be introduced maintenance intervals could not be extended to five years when docking, there still would be need to be intermediary overhauls when afloat during off-hire with no charter income.

Owner/Manager no. 6 with a fleet of 11 vessels, mainly short sea bulkers

According to the respondent;

The company was not utilising technical CM methodology, but possible benefits would be fewer inspections such as flag state, port state, vetting and class inspections.

The main obstacles for not using it were necessity, price and lack of online communication, as well as knowledge and training of the onboard personnel. Third party data evaluation was not an option since the knowledge about the status of the equipment needed to be with the crew on board.

Owner/Manager no. 7 with a fleet of 10 tankers

According to the respondent;

Some CM equipment was used but no vibration monitoring or similar. The main obstacles were the huge investments and the time it required for the office personnel to follow up so that the systems were used correctly.

There was no current strategy to implement more CM systems but the company was open to new technology that could extend maintenance intervals.

CM class might in the future be an option if it could be utilised on separate systems and not for the whole ship. A commercial gain would be expected if run properly with experienced crews that e.g. could lead to extended docking intervals in connection with charter contract extensions.

The main obstacle to implementation of more CM methods was the work load in the office. The company was open to consultancy services if the services were professional and the strategies were in accordance with the company.

Owner/Manager no. 8 with a fleet of 7 vessels, mainly Pax/RoPax ships

According to the respondent;

CM monitoring was previously used on some ships, but the previous mechanical problems had been solved and the dedicated personnel involved had left for other ships so the system was not used anymore. The data analyses were carried out on board.

There was currently no CM strategy in the company, but evaluation was made of the newer engine automation systems that were on-line via VSAT.

Otherwise there would be no benefits with CM since the ships were quite new.

Owner/Manager no. 9 with a fleet of 33 RoRo ships

According to the respondent;

Criticality analysis according RCM was about to be introduced with more centralised planning. CM might be a possible strategy in this task.

There were no technical CM systems utilised on board the company's vessels. When CM previously was used in the company the traditional surveys still had to be carried out, so the incentive was lost to continue with CM. Another factor was that the equipment was too sensitive and not suitable for the on board environment.

The main obstacle today for introduction of more CM methods was financial.

CM class is currently not on the agenda in the company. The main obstacle might be lack of knowledge about the systems and lack of dialogue with the classification society about the benefits.

Owner/Manager no. 10 with a fleet of 10 tankers

According to the respondent;

No technical CM equipment was currently used on board the company's vessels, the costs were too high for purchasing and maintenance of CM equipment.

There was currently no CM strategy in the company.

There were benefits with CM such as the possibility to see trends of equipment status, but the monitoring has to be done with continuity, and often by same person, in order to be able to get the right trend analysis.

The main obstacles for introduction of more CM methods were the costs involved and the sensitivity of CM equipment.

4.9 Classification

The documentary analysis regarding the classification societies' survey rules revealed that the major classification societies had similar rules regarding these alternative survey methods and the related machinery maintenance class notations.

A description of Det Norske Veritas alternative survey arrangements is attached (see Appendix 16).

The documentary analysis regarding the 177 vessels included in the survey showed that the vessels were classed in following classification societies:

Classification society

Lloyds Register, (LR)	77
Det Norske Veritas, (DNV)	58
Germanischer Lloyd, (GL)	19
American Bureau of Shipping, (ABS)	13
Bureau Veritas, (BV)	5
Special	3
Nippon Kaiji Kyokai, (NKK)	2
Total	**177**

Classification survey methods

The documentary analysis regarding the survey arrangements for the 177 vessels included in the survey revealed that the vessels' machinery were surveyed according the following methods:

Planned	68
Renewal, 5 years	67
Continuous	42
Total	**177**

62 % of the vessels were utilising alternative survey arrangements according either the continuous machinery or the planned maintenance systems methods.

38 % used the traditional Renewal, 5 years surveys.

None of the vessels had CM class implemented for any system.

A complete list of classification survey methods per society is attached (see Appendix 27).

Per method and vessel type:

Tankers, 71 vessels. 52 % of the tankers used the traditional 5 years renewal and 48 % the planned and continuous survey methods.

RoRo, 60 vessels. 55 % of the RoRo ships used planned, 37 % continuous and the remaining 8 % traditional survey methods.

Pax/RoPax,18 vessels. 77 % of the Pax/RoPax ships used planned and continuous and 13 % used traditional survey methods.

Bulkers/dry cargo ships, 20 vessels. 85 % of the bulkers used the traditional 5 years renewal and the rest continuous and planned survey methods.

Special service, 8 vessels. 50 % used the traditional 5 years renewal and 50 % the planned and continuous survey methods.

A complete list of classification survey methods per vessel type is attached
(see Appendix 28).

4.10 Reference industries

For reference reasons a foreign shipping company and a Swedish land based industry were further analysed regarding their maintenance management strategies.

Shipping

The shipping company referred to in this thesis was a major foreign international cruise operator that was utilising condition based maintenance (CBM) based upon condition monitoring (CM) techniques on board 14 vessels.

Land based industry

The industrial company referred to in this thesis was a Swedish paper production plant that for more than 25 years had been using monitoring technology for rotating machinery.

5 Discussion

The background for this thesis was the two previous studies presented by separate classification societies which showed that technical condition monitoring techniques were scarcely implemented on board. Only about 2 % of one society's classed fleet (Holland, 2008) and less than 1 % of the other (Sanderlien & Bühring, 2008) had certified machinery condition monitoring survey arrangements implemented.

To verify this and to find out why, a sample of owners/managers believed to be representative for the Swedish merchant fleet were selected for a survey. The companies commercially controlled about 300 and managed the 177 vessels included in the survey. To support the survey analyses of the maritime management systems market, of the classification societies' alternative machinery survey methods, of the classed fleet and a comparison with relevant reference industries were made.

The respondents addressed, who all accepted to be interviewed, were active in the owners'/managers' technical management teams. They all had solid experience in their positions, something that would grant the validity of the collected data.

The interview questionnaire was designed so it was to cover the main aim and research questions of this thesis. All respondents replied to all main as well as follow-up questions if applicable to their particular operation.
The documentary analyses were directed towards the suppliers and classifications societies own web based sources which would grant the reliability of the collected data.

The presented findings why certain strategic management decisions were made are not to be regarded as representative for the whole Swedish shipping community since a limited number of representatives were interviewed. Neither are the presented suppliers' market shares to be regarded as fully representative since a limited number of owners/managers were surveyed, despite their representation of a quite comprehensive part of the Swedish merchant fleet.

5.1 Findings

The findings in this thesis supported the two previous studies (Holland, 2008) and (Sanderlien & Bühring, 2008) regarding scarce implementation of technical condition monitoring techniques and consequent classification certification.

The documentary analysis gave a view of the maritime management systems' market and a description of the systems' and the equipment's functionality. It further revealed available survey alternatives and by which classification society the surveyed vessels belonged, as well as according which machinery maintenance arrangement the vessels in each owner's fleet were operated. In addition references from other industries were presented.

Despite that there were records from only one paper industry presented for reference reason (Koch, 2004), there were according to the findings indications that the surveyed maritime sector was lagging behind comparative fields in shore based industries when it comes to implementation of condition monitoring and condition based maintenance. There were according to the respondents various reasons for the low utilisation of CM and CBM, something that will be further elaborated upon later in this discussion.

Implementation of improved maintenance management techniques in the maritime sector I regard as supporting development safe, sustainable and efficient sea transport and operation according the Waterborne Vision 2020 agenda (Waterborne, 2007). The problem is the apparent slow rate of adopting these techniques and development of relevant maintenance strategies.

The findings further revealed that modern maintenance management techniques were not fully utilised as a part of an overall asset management strategy in the surveyed maritime field. Introduction of these techniques should be regarded as an investment, not as a cost (Kans, 2008), but there might be other rationale behind the current maintenance management strategies, something that as well will be further elaborated upon later in this discussion.

Systems market

There were four suppliers of integrated maritime management systems where the main supplier covers 32 % of the surveyed market of 177 vessels. The other three ranged between 16-22 % and the balance was covered by separate systems.

Worth noting was that none of the owners/managers were utilising the complete combined functionality for maintenance, procurement, ISM and crewing in any of the integrated software packages with full functionality available. Only one was utilising e-commerce functionality in a separate system integrated with the combined management system.

ISM management was covered both by the integrated systems with multiple functionality and by standard, as well as by proprietary systems. The integrated systems covered 42% of the surveyed market. One standard system covered 26 % and the remaining balance was covered by minor and proprietary systems.

Crew management was covered by separate systems only. One supplier covered 37 %, one 17 % and the remaining balance was covered by one minor supplier and proprietary systems.

Despite the availability of standard off the shelf systems there were still a number of active proprietary systems in this market.

There was a restructuring process amongst three of the owners/mangers where the current systems were about to be changed to systems from other suppliers, something that was expected to affect the market shares amongst the current suppliers.

Regarding technical condition monitoring equipment there were few active installations on board the vessels.

System integration

All systems were integrated ship/shore and VSAT installations were the standard way of communicating in the majority of the covered fleet. 60 % of the office systems were integrated with accounting systems, but none of the on board systems were integrated with technical condition monitoring equipment such as vibration monitoring.

The lacking on board integration was a natural consequence of the low utilisation of the CM methodology.

Maintenance management

The preventive planned maintenance was the main strategy for shipboard maintenance. The intervals were based upon the manufacturers’ recommendations in addition to gained experience. The proactive approach used by one owner/manager was regarded as a feasible method to cope with the increasing statutory, class and charterers’ inspections onboard. It was interesting that one owner/manager was looking into an updated maintenance strategy involving criticality analysis and eventually a possible RCM approach where CM could be part of the strategy.

The prevailing maintenance management strategy conformed to which machinery survey methods that were utilised in the majority of surveyed fleet of 177 vessels.

Condition monitoring strategies

Since this is the core issue in this thesis it is worthwhile to investigate somewhat more in detail.

There is a roughly a 50/50 split of the surveyed fleet and of the owners/managers regarding the utilisation of technical condition monitoring equipment, such as vibration monitoring, where one half sporadically was relying on this technology in some specific occasions and the other half not at all.

Since the implementation of condition monitoring (CM) of technical equipment was so scarcely utilised amongst the surveyed owners'/managers' fleets, the amount of preventive and other maintenance workload was likely to be higher than what would have been the case if the utilisation were better.

One of the owners/managers stated that they are planning a future strategy for implementation of more CM methods for new buildings. Four of the others said that they are open for new technology, but had no outspoken CM strategy. The rest did not have any such strategy at all.

The implementation of modern maintenance management techniques were scarcely utilised leading to that there seemed to be no clear difference in the various segments of the shipping market with regard to type, age of ships or trading patterns.

The larger tankers though with one propulsion installation had specific safety requirements both when at sea and in port, where the more traditional machinery survey pattern might be more suitable which explains the results for this particular category.

There are indications that the modern large capital and personnel intensive cruise vessels in foreign fleets were the early adopters of CM technology (Galloway, 2008), despite the fact that there for comparisons reasons were records presented from only one such owner/manager in this thesis.

The following respondents had the following comments regarding current and future CM strategies.

Owner/Manager no. 1 with a fleet of 12 vessels, mainly short sea bulkers

This owner's/manager's decision not to consider CM could due to the size and operational pattern of their fleet be regarded as a rational strategy.

Owner/Manager no. 2 with a fleet of 30 vessels, mainly RoRo ships and special tonnage

This was one of the few owners/managers that was evaluating the possibilities of CM.
The benefits were clear but a strategic decision was not yet made.

Owner/Manager no. 3 with a fleet of 30 tankers

The opinion that the costs involved and the crew's possibility to correct data evaluation of all available systems was probably one of the most representative for a common opinion amongst the owners/managers.

The benefits were known but the obstacles were higher.

Owner/Manager no. 4 with a fleet of 16 Pax/RoPax vessels

This owner/manager had experience in utilising CM technology and hade for number of reasons decided not to continue, somewhat in line with the previous respondent where the obstacles were perceived to be higher than the benefits.

Owner/Manager no. 5 with a fleet of 18 tankers

This respondent had an interesting opinion based upon history and lack of incentive for introduction of CM due to the vessels' and engines' type and the ships operating pattern, even that the benefits with lower costs were clear. Despite CM the intervals could not be extended beyond the intermediary overhaul to a full five year cycle.

Again the obstacles were higher than the benefits.

Owner/Manager no. 6 with a fleet of 11 vessels, mainly short sea bulkers

This owner's/manager's decision not to consider CM could due to the operational pattern of their fleet, installed communication equipment and costs be regarded as a rational strategy despite his awareness of possible benefits.

Owner/Manager no. 7 with a fleet of 10 tankers

This owner's/manager's decision not to utilise CM technology more could also be considered rational. Open minded, foresaw benefits, but the obstacles such as costs and work load were too high.

Owner/Manager no. 8 with a fleet of 7 vessels, mainly Pax/RoPax ships

This owner/manager had experience in utilising CM technology and had for number of reasons decided not to continue, somewhat in line with the other respondent with earlier CM experience.

The respondent said that introduction on CM on new ships was not an option. A contradicting stand point in comparison with another respondent was revealed who stated that implementation of CM on older ships was the problem.

Owner/Manager no. 9 with a fleet of 33 RoRo ships

Again an opinion based upon previous experience, here also with comments about CM equipment quality. Cost was the main obstacle despite a new approach to maintenance management including CM strategies was about to materialise.

Owner/Manager no. 10 with a fleet of 10 tankers

This owner/manager again had an opinion that could be considered representative. The benefits were known but the obstacles were high due to costs, data evaluation and CM equipment.

To summarise this part it could be stated that, despite that the benefits were known, there was a resistance amongst the owners/managers to implementation of CM technology, and thus CBM activities and consequently CM class, based on

- Cost
- Bad experience
- Inconsistent data evaluation
- Equipment quality

On the other hand this summary can be challenged by the availability of contemporary better developed condition monitoring systems and equipment with better quality, better trend and data analyses functionality at more competitive pricing.
Regarding data evaluation there are a number of options incorporated within the most modern CM systems and equipment.

There are further possibilities for automatic surveillance and data transfer to in house specialists at the owners'/managers' own offices or to manufacturers' or consultancy services providers for swift and accurate condition status and trend analyses.

Classification

The by far largest classification societies were Lloyds Register and Det Norske Veritas with together 76 % of the surveyed fleet.

62 % of the surveyed fleet utilised the continuous or planned methods where the chief engineer could perform the classification according certain rules. This was a rather natural development since the introduction of certifies computerised maintenance management systems. None of the vessels had CM class implemented.

For reasons stated above 52 % of the tankers were surveyed by the traditional 5 years renewal methods.

The continuous method was used on board RoRo ships to 92 % and on Pax/RoPax ships to 77 %. This was due to these owners'/managers' explicit strategy to keep the ships as little as possible off hire for major overhauls. Redundant propulsion systems made this a feasible approach.

The traditional renewal method was used on 85 % of the bulkers since the surveyed fleet consisted of rather small vessels with engine room personnel limited to one person.

Comparable industries

In the introduction it was stated that one of the questions that could be focused on was comparison between the shipping and shore based industries how management systems and functionality are utilised.

Shipping and land based industries are naturally not fully comparable since the ships are prone to the perils of the seas as well various loading conditions that effect the hulls of the vessels. Consequently bedplates, frames and bearing brackets for rotating machinery are exposed to a continuously changed operating environment that can affect readings from monitoring equipment. This will strain the efforts to interpret the readings' data correctly so that valid trends of the maintenance objects' status can be analysed.

Still a comparison was made since the industries probably have more in common than what differs when it comes to need for uninterrupted operation and cost savings.

Shipping

Despite that the results of this thesis revealed the scarce implementation of modern maintenance management techniques such as technical condition monitoring techniques on board the surveyed fleet of 177 vessels, there were examples of successful implementation of these techniques in the maritime domain abroad.

The shipping company referred to was a major international cruise ship operator that was utilising condition based maintenance (CBM) based upon condition monitoring (CM) techniques on board 14 vessels.

The CBM strategy involved readings by portable equipment for rotating shafts on electrical motors with fixed measuring points, on-line readings for major machinery components and eventually class certification (Galloway, 2008).

An internal company survey was performed where the following conclusions were drawn. It was important to create a CM culture and organisation where the involvement and commitment from senior officers were important factors in order to motivate the crew to a changed working pattern and an understanding of the benefits with CBM. Regular training of the crew, functioning hardware and software and integration between the CM and the maintenance management systems were also important factors (Galloway, 2008).

The benefits were according the cruise company considerably reduced labour and parts costs, possible improved operating life of each vessel and the increased safety for passengers and crew (Galloway, 2008).

Land based industry

The paper production plant referred to in this thesis had for more than 25 years been using monitoring technology for rotating machinery. One paper production machine was on-line monitored with a 440 channel system for all of the bearings (Koch, 2004).

This paper plant company stated that the condition monitoring efforts must fit into an overall maintenance strategy to enable it to work. The maintenance strategy supported reliability according RCM methodology of the equipment where CM was the foundation for pre-warnings of needed maintenance activities.

The benefits of the CM program were according this reference industry recognised when the results from the measurements directly were used to support the correct maintenance activity.

The paper production company had experienced fewer breakdowns, less spare parts consumption, better planning of the labour force, increased safety, better environment, increased quality, reduced speed losses and improved reliability (Koch, 2004).

5.2 Future development

Maritime Management Systems

The international community's demands on shipping and its stakeholders are likely to increase in the future regarding e.g. Health-, Safety-, Environment- and Quality standards.

More strengthened requirements on Security, Construction and Operation of vessels will see the light in the years to come, which will increase the need for development of even more sophisticated and integrated computer systems for the shipping industry.

Condition Monitoring / Condition Based Maintenance

Future studies within the maritime sector about the potential of improved operation and cost benefits regarding utilisation of CM and CBM should be performed, either in national or foreign companies where successful implementation of improved maintenance management techniques have materialised.

Despite CM suppliers and classification societies efforts to make CM/CBM more accepted in the maritime industry there is still a huge pedagogical task to make this happen.

Probably more cost benefits need to be communicated, even though the introduction of CM/CBM methodologies are to be considered an investment, not a cost.

An additional factor to be considered is the human element in data collection and evaluation.

Future studies

According the European strategic research agenda Waterborne one of the three pillars in the Vision 2020 is development of safe, sustainable and efficient sea transport and operation.

A study that eventually could lead to implementation of improved maintenance management techniques in the maritime sector could be regarded as supporting development in this direction (Waterborne, 2007).

Implementation of improved maintenance management techniques in the maritime sector would lead to improved operation and cost benefits, something that could be covered in future studies.

Other areas that could benefit from further studies is an in depth analysis of how satellite communication is utilised in the Swedish merchant fleet, with special focus on broadband and VSAT solutions. By which suppliers the communication is provided and how vessels could be more integrated with their home offices and e.g. suppliers of technical services such as machinery monitoring data analysis.

6 Conclusion

Maritime Management Systems

There was one major supplier of integrated maritime management systems for maintenance, procurement, ISM and crewing with a 32 % market share. Three others cover together 55 % of the market. None of the surveyed owners/managers utilised all four functionalities, if available, in the integrated packages and only one used e-commerce.

ISM management was covered by the integrated systems together to 42 % of the market and by one separate standard system to 26 %. Crew management was delivered by separate system suppliers only where one supplier covered 37 % and another 17 % of the market.

The balances above were covered by minor and proprietary systems.

There was a restructuring process amongst three of the owners/mangers regarding implementation of other systems.

Classification

The alternative survey methodologies offered today by the classification societies were adopted to 62% of the surveyed fleet regarding the continuous and planned regimes, but the CM survey regime was not utilised at all.

Condition Monitoring / Condition Based Maintenance

Despite that the benefits were known, there were amongst the owners/managers a resistance to implementation of CM technology, and thus CBM activities and consequently CM classification, based on

- Cost
- Bad experience
- Inconsistent data evaluation
- Equipment quality

Technical condition monitoring equipment such as for vibration monitoring was scarcely used.

The challenge to this is that the suppliers claim that the contemporary more developed condition monitoring systems and equipment have better quality, better trend and data analyses functionality and could be delivered at a more competitive price than the previous generation of systems. Further that implementation of CM technology should be seen as an investment leading to, as indicated by the referenced industries, more reliable operation and thus cost and revenue benefits.

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Appendices

Appendix 1, Supplier 1

Onboard systems

Maintenance

The system issues lists of maintenance due. The list will include all maintenance due, overdue and shortly due according to the period ahead selected.

Planned maintenance job completions reschedule the job for the next issue, by adding the interval to the completion date or running hours. If linked to the stock system, spare parts used can be issued from the inventory listing.

Running hour due dates are controlled by meters which record the latest hours and have a configurable expected daily rate, used to look ahead to predict expected due dates corresponding to next due hours. Meters can be physical devices or readings from running hour books.

Defect reporting module covering the ISM requirements for defect reporting and a ship information module where a mass of important general information about the vessel can be stored. Calibration readings can be stored in configurable templates.

A data transfer system enables the vessels to transfer their planned maintenance database to a floppy disk or attached to an email message ashore where an office maintenance system can import the data.

Vibration analysis link. The maintenance system can optionally link with vibration monitoring equipment. This allows the planned maintenance system to schedule when the reading needs to be taken and offer simple guidance on the corrective actions to rectify the alarm or pre-alarm condition.

Spare parts

Maximum Stock Level - the desired maximum stock level
Reorder Point - the level at or below which auto requisitions are generated
Stock on Hand - actual stock level on board
Refit Stock level - additional quantity to be requisitioned for refit/dry-dock
Minimum Order Level - minimum quantity to be requisitioned
Description - full description of item
Part Number - up to 4 supplier part numbers can be stored
Stock Location - up to 3 locations on board can be stored
Manufacturer/Supplier - up to 4 suppliers can be recorded
Unit price - unit price information
Optional Barcode Scanner integration.

Nameplate information of serial numbers, drawing numbers, types etc. is stored in a nameplate file with individual stock items linking to their equipment nameplate records. A Names & Address file holds manufacturer, supplier, delivery address and contact information.
Requisitions can be produced manually or automatically.
Stock issues, receipts and return to stock.
Stock transactions for issues, receipts, return to stock, unit price change, account code change and stock adjustments.

Procurement

Procurement system both for requisitioning and placing orders.
Purchase orders can be produced manually, from a company catalogue pick list by browsing an attached stock system, from a purchase order template produced from a copy of a previous order, or as a work order for services. Also quotes for any of the orders can be produced.
Once the orders are produced they can be outputted in a number of ways, printed out and posted, faxed or emailed.
The systems contain a budget section showing an overview of the whole ships spending budget or individual ship sections. Each individual budget is split in to monthly sections enabling full control of each sections monthly spending. Detailed reports for the whole budget or the individual sections can be produced and printed out.
Reports can be produced on all areas of the purchasing system.

Safety

Risk Assessments
COSHH Assessments
Machinery Assessments
Manual Handling Assessments
Permits to Work
Safe Systems of Work
Health Monitoring
Incident Reports
Non Conformity Note / Observation Reporting
ISPS Documents and Forms
Documents (e.g. Policies, Procedures, Responsibilities etc)

Forms

New documents or forms within the system or import of existing documents from Word or Excel
Security Levels control authority to Publish, modify or import documents
Previous published documents are stored into History
Version Numbering
Electronic Signatures
Non Conformance Notes and Observation reports
ISPS Documents and Forms with restricted access only to authorised users
Multi User system with central site issue and control

Email data transfers from office to ship and ship to office
Instant access to company policies and documents

Project

Specifications can be typed in and printed from within the program, also estimated figures for each job can be entered into the targets menu. Later the contractor's tender prices can be added to each individual job specification well before the project starts. Similarly any exclusions from the tenders can be suitably estimated. A detailed comparison of each of the prospective contractor's tender prices is available.
Each job has its own specifications, notes, reports, prices and status fields. The system will allow for current currency and exchange rates to be entered.
Report printouts are available in various formats including the financial breakdowns of specified sections.

Office systems

An office system is available for each of the programs:

Maintenance
Spare parts
Procurement
Safety
Project
(Supplier 1, 2010)

Appendix 2, Supplier 2

Onboard systems

Maintenance

Planned maintenance, Condition-based maintenance, Work Orders, Docking, Breakdown reports and analysis, Surveys and Certificates, Drawings and linked graphics, Maintenance history.

Maintenance plan, short and long term.
Maintenance description, job cards.
Class survey, control of class jobs and certificates.
EO-class survey items.
Electrical-megger testing reports.
Dry-docking specification.
Component history.
Safety control, check routines according to class and government's requirements.
Use of Report Forms, according to owner's requirements, when signing for jobs carried out.
Reports can be saved in PDF format.
Displayed lists can be exported in different formats (Excel / HTML).
Link to the Spare Part Program for information about components, spare part items, order status etc.
Control of spare part need for future maintenance.
Advanced search facilities.
Link to external documents (Word/Excel, photos, scanned documents, Internet etc.)
Optional drawing library.

Spare parts

Stock control, printing of orders w/critical stock reminder, order control, identification labels, stored data, optional drawing library, link to standard catalogues, link to Procurement and Budget programs.

Control of spare part stock (actual, max, min).
Order list, critical stock reminder.
Spare part need for future maintenance, link to the Maintenance Program.
Printing of orders; spare part orders, consumables and service orders.
Order control; control of all spare parts on order. Order history.
Identification labels; printing of labels for marking of spare parts.
Stored data; data for main groups, subgroups and suppliers. For each component, data is stored such as code no., name, drawing or part number, supplier, price, max/min stock qty., locker and shelf.
Link to the Procurement System at the owner's office for effective and convenient order handling. Sending requisitions and received items to the office, reading order status from the office.
Full data update between the vessel and the office when linked to the Procurement System at the office.
Cost control; system can be integrated with the Budget Program.

Optional drawing library.
Link to standard catalogues for consumables etc.
Advanced search facilities.
Reports can be saved in PDF format.
Displayed lists can be exported in different formats (Excel / HTML).
Link to external documents (Word/Excel, photos, scanned documents, Internet etc.)
The procurement section of the Spare Part Program can be linked with the Budget Program.
Furthermore, the onboard Budget Program can be linked to the onshore office Budget Program.

Budget

Annual Budget, Previous years' budgets, cost control, periodical budget status, Supplier status, Link with Spare Part, data interchange with office. Using Data Communication or other solutions for data exchange.
Next year's budget based on previous year's budget and status given by Spare Part / Maintenance system.
Cost control for the vessel.
Budget status per date or yearly status.
Budget status (Budget, Expenses and Remainder) for all levels in the account plan.
Budget history for all years for each account, numerical and graphical presentation.
Supplier status; status per date and report for the last year.
Link between Budget and Procurement part of Spare Part Program.
Link between Budget Program onshore and budget system onboard each vessel via data communication. (Planning of next year's budget and regular updating of vessel's vouchers)
Advanced search facilities.
Flexible Reports dialogue with filtering, reports can be saved in PDF format.
Displayed lists can be exported in different formats (Excel / HTML).

Safety

Memos
Forms
Documents
Follow up of renewal of certificates
Report and follow up during new-building projects between vessel/site office and central office.
Report and follow up of Guarantee Claims.
Q&A
Defects reporting, Incident reporting
Distribution and storing of electronic forms.
Breakdown reports
And any other reporting made by vessels and shared with central office and/or across the fleet.
Link from Planned Maintenance (break down, defects etc.)

Forms

The program onboard communicates with the office version, the filled forms can be sent to the office and new forms can be sent from the office to all the vessels.
Filling and printing of all types of forms.
Forms can be made individually for each customer.
All filled forms will be saved in a database.
Forms are communicated with owner's office.
The vessels are updated with all new forms and all forms modifications from the office.
All filled forms for all the vessels can be viewed and printed at the office.
Distribution office to vessel, vessel group and fleet.
External documents, drawings, photos etc. can be linked with a memo.
E-mails (also with attachment) may be dropped as memo or attachment.

Crew

Certificates
Visa
Vaccination
Passport
Next of kin
Monthly wages
Leave wage, overtime etc.
Preparation and printout of the monthly Wage Account with printout of the Monthly Summary.
The Wage Account form is prepared especially to suit each customer's need.
Different reports can be prepared and printed:
Crew list, IMO crew list and standard crew list.
Crew's Effects Declaration.
Vaccination Status.
Sign on / Sign off report.
Master's Cash Account.
Slopchest Account.
The reports can be saved in PDF format.

Provision

Stock control, item information from different suppliers, overview of quantity and prices, calculates provision accounts, budget control, various reports, order control, easy communication with shore office.

Control of the provision stock onboard, critical stock reminder.
Database with item information from different suppliers, unit prices in local currencies.
Achieve a good overview of quantity and prices.
Calculates provision accounts and control against budget.
Calculates and print out Reports such as:
Main groups and item list.
Requisitions for Provision.

Periodical reports.
Catering stock list with prices.

Slopchest module with :
Outprint of price list for Slopchest items.
Registration of crew members.
Registration of sale to crew with printing of reports.
Requisitions for items for Slopchest.
Periodical reports for Slopchest account.
Order control; control of all requisitions for Provision, Pantry and Slopchest. Link to Spare Part Program and Procurement Program for central administration.
The reports can be saved in PDF format.

Voyage Report

Statement of Facts
Notice of Readiness
Letter of Protest.
Crew List etc.
Forms / port reports can be made especially for each customer.
Printing Voyage Analysis for consumption and speed.
The reports can be saved in PDF format.
Link to the office version where latest position and other information will be presented for all vessels.
All vessels' reports can be transferred to the office.

Communication

Inventory onboard/ procurement ashore: orders, order updates, supplier list, spare part data, etc.
Maintenance: history, maintenance jobs, etc.
Loading calculations: loading conditions
Files from other programs, text editor, database program, spread sheet and also graphic files can be transferred via the communication program.
Creating a complete overview of all data exchange made by the supplier’s own programs.
Search the transmission history.
Use available windows devices/modems (TAPI) or select from the built in list of modems.
Effective data compression, continuation on partly sent / received files, checksum comparison and variable data block size will secure an efficient link between vessels and shore office.
Multiple communication devices (e.g. modems) in the same system. (may operate at the same time).
Control of the communication program from any computer in net, includes starting dial-up.
On connection files are transferred both ways.

Office systems

Maintenance

Includes same functionality as onboard maintenance, but for the entire fleet enabling a centralised maintenance overview and administration.

Budget

Annual Budget, Previous years' budgets, cost control, periodical budget status, Supplier status, Link with Procurement.

Procurement

Order from inquiry to invoicing, linked with Spare part onboard, printing Inquiry, Purchase Order, Courtesy Letter and Reminders. Printing Order List, Comparison of Suppliers' quotations, Supplier evaluation, link to standard catalogues and links to accounting system or E-commerce.

Safety

Includes same functionality as onboard safety, but for the entire fleet enabling a centralised overview and administration.

Voyage Report

Includes same functionality as Voyage Report Program - Vessel, but enable a centralised overview of the fleet and voyages.

Communication

The communication program is a communication tool for automating the file transfers between software onboard and software at offices ashore.
(Supplier 2, 2010)

Appendix 3, Supplier 3

Onboard systems

Maintenance

Plan preventive & corrective maintenance work
Report work done
Issue requisitions
Keep stock & handle supplies
Control plant inventory
Replicate data between ship and shore

Spare parts

Issue requisitions
Keep stock & handle supplies
Control plant inventory

Procurement

Generate or receive requisitions
Approve requisitions
Generate inquiries
Compare tenders
Generate purchase orders
Follow up deliveries
Update interacting systems with material & part prices
Receive & approve invoices
Transmit invoice, estimate & commitment data to accounting
Replicate data ship/ shore

E-commerce

Internet based e-commerce system integrated with the shipping company’s in house procurement system.
Exchange e-commerce messages on the MTML format.
Prices, terms and conditions are fed directly into the buyer's procurement system.

Near accidents and non conformities
Analyse events, decide remedial actions
Evaluate event consequences and marine insurance & warranty cover
Systems/equipment
Design/construction/material
Working methods/tools
Procedures/check lists/routines
Vendors/services

Training
Management

Forms

Issue & handle documents
Handle certificates
Linking photos & images to reports, etc
Standardise procedures across the fleet
Administer forms and form data required for ship operation
Generate reports to the different managerial levels
Replicate data between ship and shore

Insurance

Keep track of insurance policies & premium payments
Keep track of lead insurance companies & followers
Provide information and documentation for handling of claims
Follow up claim estimates, settlements, costs and reimbursements
Keep track of claims and company claims history
Provide historical records of loss ratios for different insurance companies and covers

Guarantee

Log guarantees claims or product failures during the guarantee period.
Describe the consequences of the product failure.
Manage and follow up until the product failure is fixed
Track all correspondence regarding the guarantee claim
Track all actions and costs related to the product failure and corrections
Involve ship and shore personnel through data exchange
Coordinate actions and information between ship and home office
Link with purchase order, spares parts consumption, work orders, related documents (e.g. pictures, drawings), and notifications
Technical documentation
Equipment failure consequences
Notification and communication
Corrective actions
Data replication

Project

Generate specifications
Request for quote
Receive quotes
Comparison of quotations
Award contracts

Follow-up project and cost
Change orders and extras
Settlement with yard
Report work done back in the maintenance module

Office systems

An office system is available for each of the programs:

Maintenance
Spare parts
Procurement
E-commerce
Safety
Insurance
Guarantee
Project
(Supplier 3, 2010)

Appendix 4, Supplier 4

Onboard systems

Maintenance

Plan maintenance
Define jobs to be performed regularly
Define maintenance schedules
Print lists of jobs to be done in the immediate future, as check-lists or with full descriptions
Plan extraordinary maintenance with work orders
Report maintenance
Report performance of planned maintenance, manually or semi-automatically
Keep records required by inspecting authorities
Print or display maintenance records
Report unexpected work and routine checks
Create work orders and report work based on work orders
Integration with condition based maintenance systems

Spare parts

Control stock
Display and print inventory list for each storage area
Update quantities directly, after taking inventory
Display automatic transactions in and out of stock from maintenance or procurement activities
Review current stock quantities in relation to pre-set minimum, maximum and reorder levels
Automatically calculate the amount needed to fill stock to any of those three levels
Store preferred vendor, price and vendor supplied units for all stock
Request stock
Enter desired quantities of items as they are used or expire

Procurement

Requisition stock and consumables
Create requisition forms for stock items automatically or create forms manually
Create requisition forms for consumables
Track procurement activities
Receive goods
Mark goods received based on purchase orders, automatically updating stock
Track costs and budgets
Receive requisitions
Import data from various local installations to the main office
Make queries to potential vendors
Compare quotations
Receive quotations in response to queries you send out
Record and calculate the total price of each quotation
Compare quotations
Create / approve purchase orders

Order goods
Confirm orders
Plan deliveries
Plan transport
Apply company specific workflows

E-commerce

Receive Requisitions from branch officers or ships
Make Queries to Potential Vendors
Compare Quotations
Create / Approve Purchase Orders
Order Goods
Confirm Orders
Plan Deliveries

Safety

Circulars
Claims
Incidents
Manuals
Non Conformities
Procedures
Quality work orders
Conventions
Claims
Emergency Response System
Work Flow
Self Assessment

Crew

Crew planning by employee, rank or vessel
Contracts, ranks, addresses, airports, photos, service periods, education, certificates, medical records, passports/visas
Licenses, medical certificates, ID books and services
Payroll, salary
Master's cash
Slopchest
Bonded stores
Crew welfare
Cash advance
Payment
Reimbursement
Crew effects
Ships stores
Stock items
Templates

Supernumerary
Crew change

Office systems

An office system is available for each of the programs:

Maintenance
Spare parts
Procurement
E-commerce
Safety
Crew
(Supplier 4, 2010)

Appendix 5, Supplier 5

Onboard systems

Maintenance

Machinery list
In the Machinery list technical information can be entered and remarks of many different instruments and machines. Also the parts of a machine can be entered.

All parts and maintenance points can be linked to a job card with information about that part and/or maintenance points. A week list with maintenance to be carried out is produced weekly.
A repair list, a list with critical equipment, and several overviews of executed maintenance are available.
Linking of documents to maintenance points is available.
Input of running hours.

Spare parts

The system can keep up a stock control of parts and can show deficiencies.

Certificates

Certificate management
Date of issue, date of expiry and the dates of endorsement.

Office systems

An office system is available for the program.
(Supplier 5, 2010)

Appendix 6, Supplier 6

E-commerce

The system provides functionality for:

Processing and sending Requests For Quote (RFQs) and Purchase Orders (POs).
Receiving Quotes and Order Confirmations directly in the procurement system.
Dynamic information flow.
Access to supplier product information during order placement.
Access to contracted prices.
(Supplier 6, 2010)

Appendix 7, Supplier 7

ISM

A for system accident reports, near misses and non-conformities.
The system is connected to a central system where access is provided to external parties.

Reports from ship
From the ship, the reports are sent via Internet to the Designated Person Ashore (DPA) who is the ISM responsible officer in the company.
The report is designed as a special form but may be adjusted to fit in to the company's information structure.

Report administration and feedback
The DPA administrates the reports through a validation process where the reports are communicated to other parties in the company.
Feedback to the ship is made with comments, decision on corrective actions, safety alerts and lessons learned.

Data base searches
All reports with or without attached files are stored in a database where selections can be made with searches direct in the reports, free text or through key words.
(Supplier 7, 2010)

Appendix 8, Supplier 8

ISM

The system handles procedures in a safety management system as well as non-conformities.

Document properties and categories
Search facilities
Version control
Document feedback and authorisation
Document distribution
Filing functions

Non-conformity reporting
Distribution and feed-back
Search facilities
Common database
(Supplier 8, 2010)

Appendix 9, Supplier 9

ISM

The system handles:

Event reporting (accident/loss & near accident)
Audit & inspection reports
Non-conformities & observations follow-up for the fleet
Audit/ inspection planner
Suggestion for improvements
Systematic cause analysis
Experience transfer & lesson learned
Statistics & KPI reports
(Supplier 9, 2010)

Appendix 10, Supplier 10

Crewing

The system provides functionality for:

Certificates
Enrolment
Document Management
IMO crew list
U.S. crew list
Employment Act - officers, ratings
Supports all major contracts
Export to Excel or print PDF
Report module
Tax returns
Working time accounts linked to the Journal
Rest time warnings
Ship Cash handling all currencies
TAP accounts
(Supplier 10, 2010)

Appendix 11, Supplier 11

Crewing

The system provides functionality for Personnel administration

Handling:

Time-sheets with working hours or days
Automatically calculated wages according different unions agreements
Safety management
Working time regulations
Port state control documents according IMO rules
Training and education information
Passport, health certificate and visa information
Communication module for ship/shore transfer of information
(Supplier 11, 2010)

Appendix 12, Supplier 12

Crewing

The system provides functionality for:

Crew management
Labour contracts
Training & education, safety-instruction courses
Claims
Travel arrangements
Provision
Allotments
Budgeting

Crew Planning
Documents, licenses and certificates per vessel, rank and seafarer
Sign on / sign off functions
Travel planning

Wages
Employment contracts based on international agreements
Scales linked to each rank and vessel type
Deductions and compensations
Multi currency support

Electronic Dossier
Documents
Licenses
Certificates
Medicals
Training
(Supplier 12, 2010)

Appendix 13, Supplier A

CM systems

Data collection hardware: Portable and online monitoring systems
Bearing fault identification
Vibration monitoring
Spectral analysis
Multi-level fault severity
Diagnostics
Online monitoring
Condition monitoring software
Web portal
(Supplier A, 2010)

Appendix 14, Supplier B

CM systems

Bearing condition in rotating equipment is monitored using shock pulse measurement. Vibration monitoring is used on applications where other problems such as alignment, impeller problems, gear problems, balancing problems etc. occur.

Online monitors, data loggers and other handheld instruments measure shock pulses, RMS vibration velocity, vibration time records with FFT spectrum, temperature and speed.

Online equipment includes high performance vibration analysis units as well as one or two channel alarm units.

Software handles data from all handheld instruments, data loggers, and online systems. Customer defined measurements can be manually input and the software also accepts online analog signals as voltage or current. The software contains sophisticated vibration analysis models as well as an extensive library of bearing and lubrication data and, ISO standard limits.
(Supplier B, 2010)

Appendix 15, Supplier C

CM systems

Velocity vibration reading
Comparison to ISO guidelines
Alarm display
Displacement
Enveloped acceleration
FFT spectrum analysis
Time waveform display
Temperature measurement
Condition monitoring software
(Supplier C, 2010)

Appendix 16, Alternative survey arrangements

Rules for Classification of Ships, Ships in Operation, Part 7 Chapter 1 Survey Requirements

ALTERNATIVE SURVEY ARRANGEMENTS

A. General

A 100 General overview of survey arrangements.

101 Alternative survey arrangements may be accepted as an option to applicable periodical surveys for main class.

102 The following survey arrangements may be granted upon written request from the owner:
— Hull Continuous, see B100.
— Machinery Continuous, see C100.
— Machinery PMS (Planned Maintenance System), see C200.
— Machinery CM (Condition Monitoring), a survey arrangement that is based on Machinery PMS, but allow for use of condition based maintenance methods on selected parts of the machinery, see C300.

B. Hull Survey Arrangements

B 100 Hull Continuous

101 Hull Continuous is a survey arrangement where hull compartments and structure required to be surveyed as part of the intermediate and renewal surveys may be regarded as subject to separate surveys with survey interval 2.5 years or 5 years as applicable.
The due dates for compartments and structure with survey interval 2.5 years shall normally be distributed with 40% of the surveys each year and the separate surveys shall in all cases be carried out twice in each 5 year period of the class certificate.
The due dates for compartments and structure with survey interval 5 years shall normally be distributed with 20% of the surveys each year and the separate surveys shall in all cases be carried out once in each 5 year period of the class certificate.
The time window for surveys to be carried out are generally set as 6 months before the due dates as distributed.

102 Hull Continuous may be accepted for ships less than 20 years of age and where an additional class notation as listed below, has been assigned:

Passenger Ship
Car Ferry
Train Ferry
Tanker for Liquefied Gas
Tanker for Compressed Natural Gas
Container Carrier
Ro/Ro
Multipurpose cargo ships

1) Specially arranged to carry forestry products (except timber and log carriers)
in addition normally arranged to carry containers and other unitised
cargoes and bulk parcels, normally designed with box-shaped open-hatch
holds with double bottom and double skin for the complete cargo area.

103 The survey of the outside of the ship's hull required as part of the renewal survey may be held at any time within the five year period of the class certificate.
Thickness measurements as required at renewal survey shall be carried out when the ship is surveyed in dry-dock, if not already completed.

C. Machinery Survey Arrangements
DNV Survey Requirements, Chapter 7, Part 1, Section 8, C 100
C 100 Machinery Continuous

101 Machinery Continuous is a survey arrangement where the components in the machinery list established for the vessel are subject to separate surveys with survey interval 5 years.
The due dates shall normally be distributed with 20% of the surveys each year and the separate surveys shall in all cases be carried out once in each 5 year period of the class certificate.
The time window for surveys to be carried out are generally set as 6 months before the due dates as distributed.

102 A follow-up system covering the Society's machinery list in accordance with Sec.4 Table E1 shall be established on board the ship.

103 Machinery component surveys may be credited based on documented maintenance history presented by the chief engineer.

The following conditions apply:

— the chief engineer shall hold a valid licence for the relevant machinery

— a statement signed by the company's designated person, technical director, fleet manager or similar, listing the chief engineers that are qualified to carry out the relevant jobs shall be available

— documented maintenance history shall include extract of engine logbook, maintenance history, wear measurements forms etc.

— half of all machinery component surveys, for components of which there are more than one, can be credited based on documented maintenance history presented by the chief engineer, every second time they are credited. This does not apply to complete main engines and engines in an electric propulsion system. These can not be credited based on documented maintenance history, even if more than one main engine is installed

— the surveyor can, if found necessary, require a re-survey of items surveyed by the chief engineer.

104 Survey of the following items shall be carried out by a surveyor:

— steam turbines for propulsion and power generation

— reduction gears in steam driven propulsion plants.

C 200 Machinery PMS (Planned Maintenance System)

201 Machinery PMS is a survey arrangement based on audits of an approved and implemented planned maintenance system onboard which shall cover all component surveys in the machinery list for the vessel.

The audits shall be part of the main class annual survey, see Sec.2 A200.

202 Machinery PMS shall be operated under the following conditions:

a) the chief engineer shall hold a valid licence for the relevant machinery

b) a statement signed by the company's technical director, fleet manager or similar, listing the chief engineers that are qualified to carry out the relevant jobs shall be available

c) the chief engineer may carry out survey on behalf of the Society on all component surveys in the machinery list, except for the following:

— steam turbines for propulsion and power generation

— reduction gears in steam driven propulsion plants.

d) the maintenance plan shall be regularly reviewed and systematically improved based on reported maintenance history (continuous improvement)

e) back up of the PMS database shall be taken at least once a week

f) change or a major upgrade of planned maintenance system (e.g. from DOS to WINDOWS

based system) shall always be notified to the Society and will be subject to new approval
g) the surveyor can, if found necessary, require a re-survey of items surveyed by the chief engineer.

203 The planned maintenance system onboard shall comply with the following requirements:
— the system shall be computer based
— the system shall be able to produce a maintenance history report of all main overhauls carried out for a specific time period
— corrective actions shall be possible to be especially identified in the system
— the system shall include at least the applicable machinery and equipment listed in Sec. 4 Table E1 All these components shall be identified with their belonging the Society's machinery item code or alternatively the full name of the component survey according to the machinery list for the specific ship
— all main overhaul jobs shall be identified as class related jobs in the maintenance system
— for ships with class notation E0 or ECO, the system shall also include all jobs related to these class notations. These jobs shall be especially identified in the system and include test routines and set-points based on Pt.6 Ch.3 Sec.3 Table A1 to Table A6
— scope of the annual survey and complete survey for the class notation E0 or ECO shall be included in the planned maintenance system. These jobs shall be especially identified in the planned maintenance system with maximum interval 12 months for the annual survey jobs and maximum 60 months for the complete survey jobs
— a system for tracing components that are being re-used in different positions (circulating components, e.g. piston, exhaust valve) shall be in place (included in the system or as a separate system)
— the job descriptions for the main overhaul for all the machinery and equipment subject to class shall at least cover the requirements for class survey as under survey method listed in Sec.4 Table E1. The extent of the job descriptions shall be self-explaining to a surveyor
— job intervals shall be based on maker's recommendations unless documented experience can justify changes
— the job descriptions and maintenance history shall be in English.

204 The approval process for the Machinery PMS survey arrangement is a two step process: The first step is approval of the planned maintenance system software prior to the initial survey onboard, either based on a system type approved by the Society, see 205, or a case-by-case system approval, see 205 and 206. The final step is the initial survey onboard, see 207. This process applies to each type of planned maintenance system used by the management

company.

205 If the planned maintenance system is type approved by the Society the following documentation shall be submitted by the manager before a PMS initial survey can be carried out on the first ship using this system:
a) examples on how the machinery items are included in the system, with the Society’s machinery item codes or the full name of the component survey used to identify each machinery component survey
b) description of how the jobs related to class notation E0 or ECO are identified in the system, including examples of print out of job descriptions that will cover the requirements to the class notation with special identification and interval
c) description of a system for tracing components that are being re-used in different positions (circulating components, e.g. piston, exhaust valve) shall be in place (included in the system or as a separate system)
d) job descriptions with instruction that the following shall always be surveyed by a surveyor (cannot be surveyed by the chief engineer:
— steam turbines for propulsion and power generation
— reduction gears in steam driven propulsion plants.
e) description of the manager's maintenance strategy including a chart of responsibility for the vessel and the management
f) description of routines for continuous improvement of the maintenance strategy and intervals on critical machinery systems and equipment. Important elements in this context are identification and follow-up of unplanned maintenance, recording of condition before maintenance is carried out, and recording of all changes in the planned maintenance system
g) description of backup routines.

206 If the planned maintenance system is not type approved by the Society, the following documentation shall be submitted for a case-by-case system approval, in addition to the requirements in 205:
— description of the system
— description of how postponed and overdue jobs are handled
— description of how corrective jobs are handled
— description of the procedures for planning, execution and reporting of maintenance jobs
— description of the set up of the access control in the system
— examples of maintenance history report (class report) for crediting of class machinery and equipment. The report shall at least contain component name, the Society’s machinery item

code, interval, carried out date (running hours if applicable) and maintenance history of all main overhauls carried out for a specific time period.

A system approval certificate will be issued upon satisfactory review and approval of the documentation submitted in accordance with 205-206, stating the name of the approved system.
A copy of this certificate shall be onboard every vessel that applies for the Machinery PMS survey arrangement, using a system not type approved by the Society.

207 An initial survey shall be carried out onboard the vessel in order to verify that the system has been implemented in accordance with the approved documentation and that the system is used as intended. It is required that the planned maintenance system has been operated for at least 6 months before the initial survey is carried out.
During the initial survey, it will be verified that:
— a copy of the type approval certificate or the system approval certificate is onboard
— the chief engineer is familiar with the planned maintenance system and is able to demonstrate the different functionalities in the system to the attending surveyor
— the chief engineer is in possession of a valid licence for the machinery installed onboard
— the chief engineers are listed as qualified to carry out the relevant jobs on a statement signed by the company's technical director, fleet manager or similar
— the general condition of the machinery and the machinery systems in the engine room is good
— all the requirements in 202 and 203 are complied with.

Provided the initial survey is carried out with a satisfactory result, the Machinery PMS survey arrangement will be granted and a certificate will be issued stating system name and conditions for the survey arrangement for the specific vessel.

208 The components in the machinery list are credited at the first annual survey after their main overhaul is carried out.
This also applies if the maintenance interval is based on running hours and the time between main overhauls for this reason exceeds 5 years.

209 If experience indicates that maintenance intervals may be increased, this shall be documented in the continuous improvement job. Provided the change of interval is approved by the management's organisation ashore, in agreement with Maker, this shall be documented and it may be accepted by the attending surveyor at the next annual survey.

210 Damage to machinery systems or equipment covered by classification shall always be reported to the Society and into the planned maintenance system as a corrective action. See Pt.1 Ch.1 Sec.3 B.

211 If the conditions for the survey arrangement are not complied with or in case of change of technical manager of the vessel, the survey arrangement will be cancelled and substituted by Machinery Continuous survey arrangement.

C 300 Machinery CM (Condition Monitoring)

301 Machinery CM is a survey arrangement based on audits of an approved and implemented condition monitoring programme onboard. Machinery CM allows the manager to adjust maintenance intervals based on condition monitoring of applicable components onboard the ships.

The audits shall be part of the main class annual survey, see Sec.2 A200.
See also Classification Note 10.2 for further details of requirements in 302 and 304.

302 The following conditions apply:
— the extent of condition monitoring is based on the company's own choice
— valid Machinery PMS survey arrangement shall be approved and implemented
— condition monitoring strategy shall be successfully implemented onboard
— condition monitoring shall be an implemented part of a planned maintenance system
— programme for fuel oil bunker analysis shall be implemented and documented onboard
— programme for lubricating oil analysis shall be implemented and documented onboard
— computer based diesel engine performance analyser shall be provided and in use onboard
— vibration measuring equipment and software shall be provided and in use onboard.
If propulsion steam turbines, including reduction gears shall be a part of the survey arrangement, a renewal survey will be a part of the survey arrangement. This survey shall be a voyage survey for the surveyor to verify the condition of the propulsion plant.

303 The following components, if monitored, shall be analysed by use of FFT (Fast Fourier Transformation) analysis:
— steam turbines
— electrical motors for propulsion
— reduction gears and power take off

— generators
— reciprocating machinery
— steam turbines.

304 The following documentation shall be submitted for approval:
— description of the company's maintenance strategy
— monitoring methods for components, including baseline
— condition monitoring equipment
— implementation of condition monitoring in the planned maintenance system
— training programme and plan
— programme for fuel oil bunker analysis, if applicable
— programme for lubricating oil analysis.

305 A company approval certificate will be issued upon satisfactory
review and approval of the documentation submitted in accordance with 304.

306 An initial survey shall be carried out onboard the ship in order to verify that the system has been implemented in accordance with the approved documentation.
It is required that the programme has been operated for at least 6 months before the initial survey is carried out.
Provided the initial survey is carried out with satisfactory results, the Machinery CM survey arrangement will be granted and a certificate will be issued stating conditions for the survey arrangement for the specific vessel.

307 Damage to machinery systems or equipment covered by classification shall always be reported to the Society and into the planned maintenance system as a corrective action. See Pt.1 Ch.1 Sec.3 B.

308 If the conditions for the survey arrangement are not complied with or in case of change of technical manager of the vessel, the survey arrangement will be cancelled and substituted by Machinery Continuous survey arrangement or the Machinery PMS survey arrangement.
(DNV, 2008)

Appendix 17, Owner/Manager no. 1

Owner/Manager no. 1 had a fleet of 12 vessels, mainly short sea bulkers, on technical and other management.

The company was using separate on board systems for maintenance, ISM and crewing integrated with the office systems via mobile telephone or SatCom.

No integration either on board or in the office was done with any other systems. The procurement, ISM and crewing systems were proprietary systems.

The maintenance system was a standard system handling run-time based maintenance routines, spare parts and certificates (see Appendix 5, Supplier 5).

Procurement was handled by the accounting system in the manager's office. Info was received by e.g. mail or fax from the vessels and is retyped into the accounting system. The company did not use any e-commerce system.

The on board maintenance was performed by run-time based preventive methods and by experience. Often the main engines were completely overhauled at the 5 year dockings. Almost all of the vessels were classed by GL and were surveyed according the traditional 5 years machinery renewal scheme.

The company was not utilising technical CM methodology since the ships were fairly small with only one man in the engine room. The reason for that was the considerable investment for the implementation of technical CM. There was according to the respondent currently no future strategy for implementation of more CM methods.

Fleet list, Owner/Manager no. 1

12 vessels: 10 General cargo-, 1 RoRo-, 1 Special service-ships

Vessel	Built	Type	DWT	Class	Code	Mach. survey
1	1997	GC	5 557	GL	+100 A5 E3 +MC E3	Machinery
2	2000	GC	4 135	GL	+100 A5 E3 +MC E3 AUT	Machinery
3	1983	GC	3 219	GL	+100 A5 E3 +MC E3 AUT	Machinery
4	2000	GC	4 135	GL	+100 A5 E3 +MC E3 AUT	Machinery
5	2000	GC	4 135	GL	+100 A5 E3 +MC E3 AUT	Machinery
6	1989	GC	4 329	GL	+100 A5 E3 +MC E3 AUT	Machinery
7	2000	GC	4 135	GL	+100 A5 E3 +MC E3 AUT	Machinery
8	2000	GC	4 135	GL	+100 A5 E3 +MC E3 AUT	Machinery
9	2005	GC	6 397	GL	+100 A5 E3 +MC E3 AUT	Machinery
10	1997	GC	4 168	GL	+100 A5 E3 +MC E3 AUT	Machinery
11	1982	RoRo	4 600	ABS	+A1, Ice Class IA, E, +AMS, +ACCU	SCS
12	1994	Special	6 695	LR	+100 A1 Ice Class 1A +LMC UMS	CSM

Class	
GL	10
ABS	1
LR	1

Mach. survey		
Machinery	Renewal, 5 years	10
CSM, SCS	Continuous	2

Appendix 18, Owner/Manager no. 2

Owner/Manager no. 2 had a fleet of 30 vessels, mainly RoRo-ships and special tonnage, on technical and other management.

The company was using integrated on board systems for maintenance and procurement and separate systems for ISM and crewing. The systems were integrated with the office systems via VSAT.

The company used e-commerce in the office which e.g. handled request for quotes and purchase orders. The system was linked to the integrated office procurement system (see Appendix 6, Supplier 6). The office system was integrated with the accounting system.

The integrated management system handled all maintenance and procurement routines (see Appendix 4, Supplier 4).

The ISM system handled e.g. accident reports, near misses and non-conformities (see Appendix 7, Supplier 7).

The crewing system handled e.g. documents and wages (see Appendix 10, Supplier 10).

The on board maintenance was performed by run-time based preventive methods.

The majority of the vessels were classed by LR and were surveyed according the Machinery Planned Maintenance System (MPMS) and Continuous Survey Machinery (CSM) schemes.

The company was not utilising technical CM methodology to any larger extent since it was hard to implement these systems on old ships.

On board the new buildings planned to be received technical CM-systems for vibration monitoring etc. will be installed (see Appendix 14, Supplier B).

According to the respondent there was a possible future strategy for implementation of more CM methods in connection with deliveries of the new buildings. The expected benefits were minimized maintenance costs, optimised operation, reduced costs and optimised classification routines.

Fleet list, Owner/Manager no. 2

30 vessels: 21 RoRo-, 2 General cargo-, 7 Special service-ships

Vessel	Built	Type	DWT	Class	Code	Mach. survey
13	2006	RoRo	15 000	DNV	1A1 ICE-1A* COMF-V(2) E0 NAUT-AW CLEAN BIS TMON	MPMS
14	2006	RoRo	15 000	DNV	1A1 ICE-1A* COMF-V(2) E0 NAUT-AW CLEAN BIS TMON	Machinery items
15	2007	RoRo	15 000	DNV	1A1 ICE-1A* COMF-V(2) E0 NAUT-AW CLEAN BIS TMON	Machinery items
16	1996	RoRo	11 450	LR	+100 A1 Ice 1A +LMC UMS	CSM
17	1996	RoRo	11 520	LR	+100 A1 Ice 1A +LMC UMS	CSM
18	1996	RoRo	11 560	LR	+100 A1 Ice 1A +LMC UMS	CSM
19	1987	RoRo	11 400	LR	+100 A1 Ice 1A +LMC UMS	CSM
20	1984	RoRo	11 500	LR	+100 A1 Ice 1A Super +LMC +UMS	CSM
21	1984	RoRo	11 500	LR	+100 A1 Ice 1A Super +LMC +UMS	CSM
22	2001	RoRo	15 100	LR	+100 A1 Ice 1A Super +LMC +UMS	MPMS
23	2002	RoRo	15 100	LR	+100 A1 Ice 1A Super +LMC +UMS	MPMS
24	2002	RoRo	15 100	LR	+100 A1 Ice 1A Super +LMC +UMS	MPMS
25	1984	RoRo	51 648	LR	100 A1 LMC UMS	MPMS
26	1984	RoRo	51 648	LR	+100 A1 Ice 1C +LMC UMS	MPMS
27	1984	RoRo	51 648	LR	+100 A1 Ice 1C +LMC UMS	MPMS
28	1984	RoRo	51 648	LR	+100 A1 Ice 1C +LMC UMS	MPMS
29	1985	RoRo	51 648	LR	+100 A1 Ice 1C +LMC UMS	MPMS
30	1998	RoRo	26 169	LR	100 A1 LMC UMS	CSM
31	1999	RoRo	26 169	LR	100 A1 LMC UMS	CSM
32	2001	RoRo	26 169	LR	100 A1 LMC UMS	CSM
33	2000	RoRo	26 169	LR	100 A1 LMC UMS	Engine
34	2005	GC	16 600	LR	+100 A1 Ice 1A Super +LMC +UMS	MPMS
35	1993	GC	5 700	DNV	1A1 ICE-1A General Cargo Carrier E0	Machinery items
36	2000	Special	2 600	DNV	1A1 ICE-10 SF E0 DYNPOS-AUTR NAUT-OC DK(+) HL(2.8)	MPMS
37	2000	Special	2 600	DNV	1A1 ICE-10 SF E0 DYNPOS-AUTR NAUT-OC DK(+) HL(2.8)	MPMS
38	2001	Special	2 600	DNV	1A1 ICE-10 SF E0 DYNPOS-AUTR NAUT-OC DK(+) HL(2.8)	MPMS
39	1989	Special	4 906	GL	100 A5 ARC3 G54 MC ARC3 AUT	Machinery
40	1974	Special	1 380	Special		Machinery
41	1975	Special	2 570	Special		Machinery
42	1977	Special	2 600	Special		Machinery

Class

LR	19
DNV	7
Special	3
GL	1

Mach. survey

MPMS	Planned	13
CSM	Continuous	9
Engine, Machinery, Mach. items	Renewal, 5 years	8

Appendix 19, Owner/Manager no. 3

Owner/Manager no. 3 had a fleet of 30 tankers on technical and other management.

The company was using integrated on board systems for maintenance, procurement and ISM, and a separate proprietary crewing systems. The systems were integrated with the office systems via SatB. The office system was integrated with the accounting system.

The integrated management system included all required functions for maintenance, procurement and ISM (see Appendix 1, Supplier 1). The company did not use e-commerce functionality.

The on board maintenance was performed by run-time based preventive methods and by a proactive approach to meet vetting and statutory inspection requirements. Often the main engines were completely overhauled at the 5 year dockings since tankers with one engine installations are difficult to maintain when at sea, as well as in port for stand by reasons according to the respondent.

The majority of the vessels were classed by DNV and a large amount by ABS. The majority were surveyed according the traditional machinery renewal scheme for the above reasons, but close to 50 % used the continuous and planned methods.

The company was not utilising technical CM methodology as a strategy. Measurements were taken on certain equipment when problems need to be temporarily monitored. There were some efforts to introduce CM equipment when specifying newbuildings. According to the respondent CM equipment was also included in the engine manufacturers' deliveries of more sophisticated electronically controlled engines, such as modern engines equipped with common rail technology.

The possible benefits with more CM were early warnings for break downs.

If it could be established that certain break downs were caused by lacking CM data, the process to implement CM equipment and systems would accelerate.

According to the respondent the main obstacles with CM technology were the costs involved for implementing the systems. Another cause was the crew's capability to evaluate the data correctly if there were too many different systems indicating operational malfunctions.

Fleet list, Owner/Manager no. 3

30 Tankers

Vessel	Built	Type	DWT	Class	Code	Mach. survey
43	2005	Tanker	149 990	ABS	+A1 E +AMS +ACCU VEC-L TCM SH ES RES SHCM ESP CRM	PM
44	2000	Tanker	149 994	ABS	+A1, E, +AMS, +ACCU, VEC-L, TCM, SH, ESP, CRC	PM
45	2001	Tanker	149 999	ABS	+A1, E, +AMS, +ACCU, VEC-L, SH, ESP, CRC	PM
46	2000	Tanker	149 999	ABS	+A1, E, +AMS, +ACCU, VEC-L, SH, ESP, CRC	PM
47	2007	Tanker	149 999	ABS	+A1, E, +AMS, +ACCU, VEC-L, FL 30, SH, ES, RES, SHCM, ESP	PM
48	2002	Tanker	159 999	ABS	+A1, E, +AMS, +ACCU, VEC-L, SH, ESP, CRC	SCS
49	1998	Tanker	157 411	DNV	+1A1 ESP E0 CCO LCS-SID VCS-2B CSA-1 ESP, CRC, CPP	Machinery items
50	2002	Tanker	150 000	ABS	+A1, E, +AMS, +ACCU, VEC-L, SH	SP
51	1997	Tanker	149 591	DNV	+1A1 ESP E0 LCS-SI	Machinery items
52	2006	Tanker	113 600	DNV	+1A1 ICE-1A ESP E0 TMON NAUTICUS	Machinery items
53	2006	Tanker	113 600	DNV	+1A1 ICE-1A ESP E0 TMON NAUTICUS	Machinery items
54	2005	Tanker	72 600	DNV	+1A1 ESP E0 VCS-2 TMON NAUTICUS	Machinery items
55	2004	Tanker	72 736	ABS	A1, AMS, ACCU, VEC, ESP, CRC	SCS
56	2005	Tanker	72 600	DNV	+1A1 ESP E0 VCS-2 TMON NAUTICUS	Machinery items
57	2006	Tanker	65 200	DNV	+1A1 ICE-1B ESP RPS E0 NAUT-AW VCS-2 PLUS-2 ETC TMON	Machinery items
58	2008	Tanker	65 200	DNV	+1A1 ICE-1B ESP RPS E0 NAUT-AW VCS-2 PLUS-2 ETC TMON	Machinery items
59	2009	Tanker	65 200	DNV	+1A1 ICE-1B ESP RPS E0 NAUT-AW VCS-2 PLUS-2 ETC TMON	Machinery items
60	2006	Tanker	65 200	DNV	+1A1 ICE-1B ESP RPS E0 NAUT-AW VCS-2 PLUS-2 ETC TMON	Machinery items
61	2009	Tanker	65 200	DNV	+1A1 ICE-1B ESP RPS E0 NAUT-AW VCS-2 PLUS-2 ETC TMON	Machinery items
62	2005	Tanker	65 125	DNV	+1A1 ICE-1B ESP RPS E0 NAUT-AW VCS-2 PLUS-2 ETC TMON	Machinery items
63	2006	Tanker	65 125	DNV	+1A1 ICE-1B ESP RPS E0 NAUT-AW VCS-2 PLUS-2 ETC TMON	Machinery items
64	2002	Tanker	47 465	LR	+100A1, ESP, SPM, LI, *IWS, +LMC UMS IGS	CSM
65	2004	Tanker	47 323	DNV	+1A1 ESP SPM E0 VCS-2 BIS ERS	MPMS
66	2003	Tanker	47 400	DNV	+1A1 G79 ESP SPM E0 VCS-2 BIS ERS	MPMS

Vessel	Built	Type	DWT	Class	Code	Mach. survey
67	2005	Tanker	47 400	DNV	+1A1 ESP SPM E0 LCS-SID VCS-2 ETC TMON ERS	Machinery items
68	2004	Tanker	47 400	ABS	A1, AMS, ACCU, VEC, ESP	SCS
69	2005	Tanker	47 400	DNV	+1A1 ESP SPM E0 LCS-SID VCS-2 ETC TMON ERS	Machinery items
70	2003	Tanker	47 136	DNV	+1A1 ESP SPM E0 VCS-2 BIS ERS	Machinery items
71	2002	Tanker	9 996	ABS	+A1, E, +AMS, +ACCU, VEC, ESP,CRC	SCS
72	2002	Tanker	9 996	ABS	+A1, Oil Carrier, E, +AMS, +ACCU, VEC, ESP,CRC	SCS

Class	
DNV	18
ABS	11
LR	1

Mach. survey		
Machinery items, SP	Renewal, 5 years	17
MPMS, PM	Planned	7
CSM, SCS	Continuous	6

Appendix 20, Owner/Manager no. 4

Owner/Manager no. 4 had a fleet of 16 Pax/RoPax-vessels on technical and other management.

The company was using integrated on board systems for maintenance and procurement and to some extent for ISM. There were also separate systems for ISM and crewing. The systems were integrated with the office systems via VSAT.

The office system was integrated with the accounting system.

The integrated management system included all required functionality for maintenance and procurement (see Appendix 4, Supplier 4).

The ISM system handled e.g. accident reports, near misses and non-conformities (see Appendix 7, Supplier 7). The crewing system handled e.g. personnel planning and wages (see Appendix 11, Supplier 11).

The on board maintenance was performed by run-time based preventive methods and by experience according to the respondent.

The majority of the vessels were classed by LR and were surveyed according the Planned Maintenance System (MPMS) scheme.

The company was currently not utilising technical CM methodology to any larger extent. Some old CM equipment was used. According to the respondent CM was no longer included in the company's maintenance philosophy such as it were 10-15 years ago when it was used extensively. CM had declined due to for shipping not properly adapted CM equipment, difficulties with easy presentation of the CM results and a common standard for evaluation of the data. Another factor was the personnel intensity for the huge amount of data that needed to be collected and evaluated. According to the respondent purchasing third party CM evaluation consultancy was not an option.

There was no explicit CM strategy but the company was open to new technology when it had proven to be reliable.

Generally the benefit with condition based maintenance was that no maintenance activities are carried out in vain, and that the overhaul frequencies can be extended. According the respondent one of the obstacles to carry out CBM was that the company can have up to six persons to fulfil an engineer's position on board. Data analyses carried out by so many people caused varied results.

Measurements and analyses could be carried out by designated teams for the whole company, but since the ferries were equipped with redundant technical systems, the benefits had not verified the costs. Imminent break downs should have had to be detected often in order to justify the investments and administration costs according to the respondent.

Fleet list, Owner/Manager no. 4

16 vessels: 13 Pax/RoPax-, 3 RoRo-ships

Vessel	Built	Type	GRT	Class	Code	Mach. survey
73	1986	Pax/RoPax	31 910	LR	100A1 LMC UMS	MPMS
74	1997	Pax/RoPax	8 631	DNV	1A1 HSLC R1 A E0 ICS	Machinery items
75	1983	Pax/RoPax	28 727	DNV	1A1 ICE-1B A E0	MPMS
76	1987	Pax/RoPax	39 178	LR	+100A1 +LMC UMS	MPMS
77	1996	Pax/RoPax	29 691	LR	+100A1 +LMC UMS	MPMS, MCM
78	2000	Pax/RoPax	24 206	LR	+100A1 +LMC UMS	MPMS
79	1981	Pax/RoPax	33 750	LR	+100A1 +LMC UMS	MPMS
80	1988	Pax/RoPax	39 169	LR	+100A1 +LMC UMS	MPMS
81	1992	Pax/RoPax	10 918	LR	+100A1 +LMC UMS	MPMS
82	1998	Pax/RoPax	42 705	LR	100A1 LMC UMS	CSM
83	1982	Pax/RoPax	20 028	LR	+100A1 +LMC UMS Suspended	CSM
84	1989	Pax/RoPax	4 296	DNV	1A1 R45	Machinery items
85	1987	Pax/RoPax	4 296	DNV	1A1 R3	Machinery items
86	1973	RoRo	6 726	LR	100A1 LMC	CSM
87	2004	RoRo	12 350	DNV	1A1 ICE-1A DG-P E0 ICS NAUT-AW	Machinery items
88	2004	RoRo	10 048	DNV	1A1 ICE-1C DG-P E0 ICS TMON	Machinery items

Class

LR	10
DNV	6

Mach. survey

MPMS	Planned	8
Machinery items	Renewal, 5 years	5
CSM	Continuous	3

Appendix 21, Owner/Manager no. 5

Owner/Manager no. 5 had a fleet of 18 tankers on technical and other management.

The company was using integrated on board systems for maintenance and procurement and separate proprietary systems for ISM and crewing, but the systems were currently under restructuring. The systems were integrated with the office systems via VSAT.

The current integrated management system (see Appendix 2, Supplier 2).

According to the respondent the on board maintenance was performed by run-time based preventive methods, by experience and by some Condition Based methods.

The majority of the vessels were classed by DNV and close to 50 % were surveyed according the Planned Maintenance (MPMS) and Continuous Survey Machinery (CSM) schemes.

No general utilisation of CM equipment, but vibration monitoring could be utilised as test and evaluation installations, e.g. onboard one vessel that currently had problems with a shaft generator. The systems were not integrated. Data evaluation was performed by the supplier who had delivered the monitoring equipment (see Appendix 13 & 15, Suppliers A & C). There was no overall CM strategy in the company but if CM would be introduced it would, according to the respondent, have lead to lower overall maintenance costs.

According to the respondent one of the obstacles for introduction of more CM methods could be that shipping was a conservative business. Another factor was that even if CM would be introduced maintenance intervals could not be extended to five years when docking, there still would need to be intermediary overhauls when afloat during off-hire with no charter income.

Fleet list, Owner/Manager no. 5

18 Tankers

Vessel	Built	Type	DWT	Class	Code	Mach. survey
89	1999	Tanker	16 376	DNV	+1A1 ICE-1A ESP E0 NAUT-OC HL(1.5) ETC	MPMS
90	1999	Tanker	16 326	DNV	+1A1 ICE-1A ESP E0 NAUT-OC HL(1.5) ETC	MPMS
91	2007	Tanker	14 737	DNV	+1A1 ICE-1C ESP RP E0 NAUT-AW VCS-2 CLEAN	Machinery items
92	2006	Tanker	14 907	DNV	+1A1 ICE-1C ESP RP E0 NAUT-AW VCS-2 CLEAN	Machinery items
93	1999	Tanker	14 359	LR	+100 A1SG1.55 ESP *IWS LI	MPMS
94	2008	Tanker	16 979	DNV	1A1 ICE-1A ESP E0 VCS-2 HL(1.54) ETC TMON	Machinery items
95	2006	Tanker	14 766	DNV	+1A1 ICE-1C ESP RP E0 NAUT-AW VCS-2 CLEAN	Machinery items
96	2006	Tanker	14 846	DNV	+1A1 ICE-1C ESP RP E0 NAUT-AW VCS-2 CLEAN	Machinery items
97	2004	Tanker	7 108	GL	+100 A5 E ESP T3D10 T4D21 MC E AUT	Machinery
98	2003	Tanker	7 157	GL	+100 A5 E ESP T3D10 T4D21 MC E AUT	Machinery
99	2008	Tanker	16 740	DNV	1A1 ICE-1A ESP E0 VCS-2 HL(1.54) TMON	Machinery items
100	2008	Tanker	16 800	DNV	1A1 ICE-1A ESP E0 VCS-2 HL(1.54) ETC TMON	Machinery items
101	2007	Tanker	16 550	DNV	1A1 ICE-1A ESP E0 VCS-2 HL(1.54) ETC INERT TMON	MPMS
102	2007	Tanker	16 550	DNV	1A1 ICE-1A ESP E0 VCS-2 HL(1.54) ETC INERT TMON	MPMS
103	2007	Tanker	16 550	DNV	1A1 ICE-1A ESP E0 VCS-2 HL(1.54) ETC INERT TMON	MPMS
104	2007	Tanker	16 550	DNV	1A1 ICE-1A ESP E0 VCS-2 HL(1.54) ETC INERT TMON	MPMS
105	2008	Tanker	16 550	DNV	1A1 ICE-1A ESP E0 VCS-2 HL(1.54) ETC INERT TMON	Machinery items
106	2008	Tanker	16 550	DNV	1A1 ICE-1A ESP E0 VCS-2 HL(1.54) ETC INERT TMON	MPMS

Class

DNV	15
GL	2
LR	1

Mach. survey

Machinery, Machinery items	Renewal, 5 years	9
MPMS	Planned	8
CSM	Continuous	1

Appendix 22, Owner/Manager no. 6

Owner/Manager no. 6 had a fleet of 11 vessels, mainly short sea bulkers, on technical and other management.

The company was using a proprietary integrated on board systems for maintenance, procurement and ISM and a separate crewing system integrated with the office systems via SatB. Integration with the crewing system was partly made in the office. Full integration with a proprietary accounting system was also done.

The crewing system that handled crew management and planning as well as wages was a standard system (see Appendix 12, Supplier 12).

The on board maintenance was according to the respondent performed by run-time based preventive methods and by experience.

Almost all of the vessels were classed by LR. About 50 % were surveyed according the traditional machinery renewal scheme and 50 % by CSM.

The company was not utilising technical CM methodology, but possible benefits would according to the respondent have been fewer inspections such as flag state, port state, vetting and class inspections.

The main obstacles for not using it were necessity, price and lack of online communication, as well as knowledge and training of the onboard personnel according to the respondent. Third party data evaluation was not an option since the knowledge about the status of the equipment needed according to the respondent to be with the crew on board.

Fleet list, Owner/Manager no. 6

11 vessels: 8 Dry cargo ships, 3 Tankers

Vessel	Built	Type	DWT	Class	Code	Mach. survey
107	1984	GC	6 150	LR	100A1 LMC UMS	Engine
108	2000	GC	3 171	GL	+100A5 E3	Machinery
109	1991	GC	3 015	BV	38E529	Machinery
110	1984	GC	6 150	LR	100A1 LMC UMS	CSM
111	1995	GC	3 519	GL	100 A5 E2 MC AUT	Machinery
112	2000	GC	3 171	GL	+100A5 E3	Machinery
113	1983	GC	6 150	LR	100A1 LMC UMS	CSM
114	1984	GC	3 175	LR	100A1 LMC UMS	Engine
115	1989	Tanker	6 793	LR	+100A1 +LMC UMS	CSM
116	1989	Tanker	6 793	LR	+100A1 +LMC UMS	CSM
117	1989	Tanker	6 793	LR	+100A1 +LMC UMS	CSM

Class

LR	7
GL	3
BV	1

Mach. survey

Engine, Machinery	Renewal, 5 years	6
CSM	Continuous	5

Appendix 23, Owner/Manager no. 7

Owner/Manager no. 7 had a fleet of 10 tankers on technical and other management.

The company was using integrated on board systems for maintenance and procurement and a separate proprietary systems for ISM and a standard system for crewing, but the systems were currently under restructuring. The systems were integrated with the office systems via SatB and VSAT.

The current integrated management system handled all required functions for maintenance and procurement (see Appendix 2, Supplier 2).

The current crewing system handled e.g. personnel planning and wages (see Appendix 11, Supplier 11).

According to the respondent the on board maintenance was performed by run-time based preventive methods and by experience.

The vessels were almost equally spread amongst BV, DNV and GL. All were surveyed according the traditional 5 years renewal scheme, but the class belonging of the vessels were according to the respondent currently under restructuring.

Some CM equipment was used but no vibration monitoring or similar. The main obstacles were according to the respondent the huge investments and the time it requires for the office personnel to follow up so that the systems were used correctly.

There was no current strategy to implement more CM systems but the company was open to new technology that could extend maintenance intervals.

CM class might according to the respondent in the future be an option if it could be utilised on separate systems and not for the whole ship. A commercial gain would be expected if run properly with experienced crews that e.g. could lead to extended docking intervals in connection with charter contract extensions.

The main obstacle to implementation of more CM methods was according to the respondent the work load in the office. The company was open to consultancy services if the services are professional and the strategies were in accordance with the company’s.

Fleet list, Owner/Manager no. 7

10 Tankers

Vessel	Built	Type	DWT	Class	Code	Mach. survey
118	2006	Tanker	11 249	BV	ESP, AUT-MS, ICE 1A	Machinery
119	2006	Tanker	9 189	DNV	ESP, E0, ICE 1A	Machinery items
120	2006	Tanker	9 181	DNV	1A1 ICE-1A ESP E0 TMON	Machinery items
121	1990	Tanker	8 490	GL	+100 A5 E2 ESP Ice 1B	Machinery items
122	2003	Tanker	7 082	BV	1 3/3 E+, ESP AUT MS, Ice III	Machinery items
123	1991	Tanker	7 070	GL	+100 A5E3 ESP, Ice 1 A	Machinery items
124	1991	Tanker	7 035	GL	+100 A5E3 ESP, Ice 1 A	Machinery items
125	2004	Tanker	4 514	BV	ESP, Ice 1B	Machinery items
126	2005	Tanker	4 513	BV	ESP, Ice 1B	Machinery items
127	1997	Tanker	2 490	DNV	1A1, E0, Ice 1B	Machinery items

Class*	
BV	4
DNV	3
GL	3

Mach. survey*		
Machinery, Machinery items	Renewal, 5 years	10

* The class and the survey methods are under restructuring during 2010

Appendix 24, Owner/Manager no. 8

Owner/Manager no. 8 had a fleet of 7 vessels, mainly Pax/RoPax-ships, on technical and other management.

The company was using integrated on board systems for maintenance and procurement and separate systems for ISM and crewing. The systems were integrated with the office systems via VSAT. Integration was done in the office with the accounting system.

The integrated management system included all required functions for maintenance and procurement (see Appendix 3, Supplier 3).

The ISM system handled e.g. documents and non-conformities (see Appendix 8, Supplier 8).

The crewing system handled e.g. personnel planning and wages (see Appendix 11, Supplier 11).

The on board maintenance was according to the respondent performed by run-time based preventive methods.

Almost all of the vessels were classed by LR and were surveyed according the CSM scheme.

According to the respondent CM monitoring was previously used on some ships, but the previous mechanical problems had been solved and the dedicated personnel involved had left for other ships so the system was not used anymore. The data analyses were carried out on board.

There was currently no CM strategy in the company, but evaluation was made of the newer engine automation systems that are on-line via VSAT according to the respondent.

Otherwise there would according to the respondent be no benefits with CM since the ships were quite new.

Fleet list, Owner/Manager no. 8

7 vessels: 5 Pax/RoPax-, 2 RoRo-ships

Vessel	Built	Type	GRT	Class	Code	Mach. survey
128	2006	Pax/RoPax	6 554	LR	+100A1, SSC (B), HSC, LDC, G3, +LMC, UMS, IBS NAV	CSM
129	1999	Pax/RoPax	5 632	LR	+100A1, SSC (B), HSC, LDC, G3, +LMC, UMS	CSM
130	2003	Pax/RoPax	29 746	LR	100 A 1 IWS , LI , LMC , UMS , NAV , IBS	CSM
131	2003	Pax/RoPax	29 746	LR	100 A 1 IWS , LI , LMC , UMS , NAV , IBS	CSM
132	1997	Pax/RoPax	17 046	DNV	+1A1, MCDK, E0	Machinery items
			DWT			
133	1979	RoRo	2 287	LR	+100A1+LMC UMS	CSM
134	1982	RoRo	2 044	LR	+100A1+LMC UMS	CSM

Class

LR	6
DNV	1

Mach. survey

CSM	Continuous	6
Machinery items	Renewal, 5 years	1

Appendix 25, Owner/Manager no. 9

Owner/Manager no. 9 had a fleet of 33 RoRo-ships on technical and other management.

The company was using integrated on board systems for maintenance, procurement and ISM and a separate crewing system. The systems were integrated with the office systems via VSAT. Integration was done in the office with the accounting system.

The integrated management system handled all required functions for maintenance procurement and ISM (see Appendix 3, Supplier 3).

The crewing system handled e.g. personnel planning and wages (see Appendix 11, Supplier 11).

The on board maintenance was according to the respondent performed by run-time based preventive methods and criticality analysis according RCM was about to be introduced with more centralised planning. CM might be a possible strategy in this task.

Almost all of the vessels were classed by LR and were surveyed according the MPMS scheme.

There were according to the respondent no technical CM systems utilised on board the company’s vessels. When CM previously was used in the company the traditional surveys still had to be carried out, so the incentive was according to the respondent lost to continue with CM. Another factor was that the equipment was too sensitive and not suitable for the on board environment. The main obstacle today for introduction of more CM methods was according to the respondent financial.

According the respondent CM class was currently not on the agenda in the company. The main obstacle might be lack of knowledge about the systems and lack of dialogue with the classification society about the benefits.

Fleet list, Owner/Manager no. 9

33 RoRo-vessels

Vessel	Built	Type	DWT	Class	Code	Mach. survey
135	2008	RoRo	30 134	LR	+100A1 *IWS LI +LMC UMS	CSM
136	2008	RoRo	30 089	LR	+100A1 *IWS LI +LMC UMS	MPMS
137	2008	RoRo	30 086	LR	+100A1 *IWS LI +LMC UMS	MPMS
138	2007	RoRo	30 137	LR	+100A1 *IWS LI +LMC UMS	MPMS
139	2007	RoRo	18 700	LR	+100A1 *IWS LI +LMC UMS	MPMS
140	2006	RoRo	22 564	LR	+100A1 *IWS LI +LMC UMS	MPMS
141	2006	RoRo	22 564	LR	+100A1 *IWS LI +LMC UMS	MPMS
142	2003	RoRo	28 388	LR	+100A1 *IWS LI +LMC UMS	MPMS
143	1999	RoRo	28 126	LR	+100A1 *IWS LI +LMC UMS	MPMS
144	1999	RoRo	28 360	LR	+100A1 *IWS LI +LMC UMS	MPMS
145	1999	RoRo	28 126	LR	+100A1 *IWS LI +LMC UMS	MPMS
146	1998	RoRo	28 142	LR	+100A1 *IWS LI +LMC UMS	MPMS
147	1997	RoRo	28 142	LR	+100A1 *IWS LI +LMC UMS	MPMS
148	1997	RoRo	28 142	LR	+100A1 *IWS LI +LMC UMS	MPMS
149	1995	RoRo	15 199	LR	+100A1 *IWS LI +LMC UMS	MPMS
150	1995	RoRo	15 199	LR	+100A1 *IWS LI +LMC UMS	MPMS
151	1985	RoRo	28 070	LR	+100A1 CR LI Ice Class 3 +LMC UMS	MPMS
152	1985	RoRo	28 070	LR	+100A1 CR LI Ice Class 3 +LMC UMS	MPMS
153	1985	RoRo	28 396	LR	+100A1 CR LI Ice Class 3 +LMC UMS	MPMS
154	1977	RoRo	13 446	LR	+100A1 LI Ice Class 3 +LMC UMS	MPMS
155	1977	RoRo	13 438	LR	+100A1 LI Ice Class 3 +LMC UMS	MPMS
156	1986	RoRo	17 176	NKK	NS*(VC)/MNS*MPP, LSA, RCF, M0.A	CMS
157	1986	RoRo	17 271	NKK	NS*(VC)/MNS*MPP, LSA, RCF, M0.A	CMS
158	1983	RoRo	12 527	LR	100A1 LMC UMS	CSM
159	1983	RoRo	12 577	LR	100A1 Ice Class 1C FS LMC UMS	CSM
160	1983	RoRo	12 562	LR	100A1 Ice Class 1C FS LMC UMS	CSM
161	1983	RoRo	12 466	LR	100A1 LMC UMS	CSM
162	1982	RoRo	28 566	LR	+100A1 LI Ice Class 1C FS +LMC UMS	MPMS
163	1982	RoRo	28 100	LR	+100A1 LI Ice Class 3 +LMC UMS	MPMS
164	1981	RoRo	28 210	LR	+100A1 *IWS LI Ice Class 3 +LMC UMS	MPMS
165	1981	RoRo	28 223	LR	+100A1 LI Ice Class 3 +LMC UMS	MPMS
166	1978	RoRo	12 197	LR	100A1 LMC UMS Suspended	CSM
167	1978	RoRo	12 178	LR	100A1 LMC UMS Suspended	CSM

Class		
LR		31
NKK		2
Mach. survey		
MPMS	Planned	24
CMS, CSM	Continuous	9

Appendix 26, Owner/Manager no. 10

Owner/Manager no. 10 had a fleet of 10 tankers on technical and other management.

The company was using integrated on board systems for maintenance and procurement and a separate system for ISM and a proprietary crewing system. The ISM system was currently under restructuring. The systems were integrated with the office systems via VSAT.

The integrated management system included all required functionality for maintenance and procurement (see Appendix 4, Supplier 4). The current ISM system handled accident reports, near misses and non-conformities (see Appendix 9, Supplier 9).

The on board maintenance was according to the respondent performed by run-time based preventive methods and by experience.

The majority of the vessels were classed by DNV and all are surveyed according the Planned Maintenance (MPMS) and Continuous Survey Machinery (CSM & SCS) schemes.

No technical CM equipment was according to respondent currently used on board the company's vessels, the costs were too high for purchasing and maintenance of CM equipment.

There was currently no CM strategy in the company. There were according to the respondent benefits with CM such as the possibility to see trends of equipment status, but the monitoring had to be done with continuity, and often by same person, in order to be able to get the right trend analysis. The main obstacles for introduction of more CM methods were according to the respondent the costs involved and the sensitivity of CM equipment.

Fleet list, Owner/Manager no. 10

10 Tankers

Vessel	Built	Type	DWT	Class	Code	Mach. survey
168	1996	Tanker	44 999	DNV	+1A1 ESP E0 CCO NAUT-OC LCS-SID HL (1.6) ETC	MPMS
169	1996	Tanker	44 999	DNV	+1A1 ESP E0 CCO NAUT-OC LCS-SID HL (1.6) ETC	MPMS
170	1996	Tanker	44 999	ABS	A1, AMS, ACCU. ESP	SCS
171	2002	Tanker	44 999	DNV	+1A1 ESP E0 CCO W1 LCS(DIS) VCS-2 HL(1.6) ETC	MPMS
172	2003	Tanker	44 999	DNV	+1A1 ESP E0 CCO W1 LCS(DIS) VCS-2 HL(1.6) ETC	MPMS
173	2003	Tanker	44 999	DNV	+1A1 ESP E0 CCO W1 LCS(DIS) VCS-2 HL(1.6) ETC	MPMS
174	2004	Tanker	44 999	DNV	+1A1 ESP E0 CCO W1 LCS(DIS) VCS-2 HL(1.6) ETC	MPMS
175	2004	Tanker	44 999	DNV	+1A1 ESP E0 CCO W1 LCS(DIS) VCS-2 HL(1.6) ETC	MPMS
176	2004	Tanker	44 999	DNV	+1A1 ESP E0 CCO W1 LCS(DIS) VCS-2 HL(1.6) ETC	MPMS
177	2010	Tanker	46 067	LR	+100A1 ESP, ShipR(SDA, FDA, CM) *IWS, LI, SPM, +LMC, UMS	CSM

Class

DNV	8
ABS	1
LR	1

Mach. survey

MPMS	Planned	8
CSM, SCS	Continuous	2

Appendix 27, Classification survey methods per society

The documentary analysis regarding the survey arrangements for the 177 vessels included in the survey reveal that the vessels' machinery is surveyed according the following methods per classification society:

LR		**ClassDirect**	
MPMS	Machinery Planned Maintenance Scheme	Planned	41
CSM	Continuous Survey Machinery	Continuous	33
Engine	Periodic	5 years	3
			77
Det Norske Veritas, DNV		**DNV Exchange**	
Machinery items	Periodic	5 years	36
MPMS	Machinery Planned Maintenance System	Planned	22
MC	Machinery Continuous	Continuous	0
			58
GL		**Fleet online**	
Class Renewal Machinery	Periodic	5 years	**19**
ABS		**Eagle Operate**	
SCS	Special Continuous Survey Machinery	Continuous	7
PM	Preventative Maintenance	Planned	5
SP	Special Periodical	5 years	1
			13
BV		**VeriSTAR**	
Machinery	Periodic	5 years	**5**
Special			
Machinery	Periodic	5 years	**3**
NKK		**Class NK**	
CMS	Continuous Machinery Survey	Continuous	**2**
Total			**177**

Appendix 28, Classification survey methods per vessel type

The documentary analysis regarding the survey arrangements for the 177 vessels included in the survey reveal that the vessels' machinery is surveyed according the following methods per type of vessel.

Per machinery survey method per type of vessel:

Tankers	Renewal, 5 years	37
	Planned	23
	Continuous	11
		71
RoRo	Planned	33
	Continuous	22
	Renewal, 5 years	5
		60
Bulkers	Renewal, 5 years	17
	Continuous	2
	Planned	1
		20
Pax/RoPax	Planned	8
	Continuous	6
	Renewal, 5 years	4
		18
Special	Renewal, 5 years	4
	Planned	3
	Continuous	1
		8
Total		**177**

Appendix 29, Questionnaire

Question 1

Is your company using any integrated on board management system for maintenance, procurement, ISM, and crewing?

Question 2

If so, from which supplier(s) and which type of functionality regarding maintenance, procurement including e-commerce, ISM, and crewing? Onboard how many ships?

Question 3

Which separate systems are used for maintenance, procurement including e-commerce, ISM, and crewing? On board how many ships?
Maintenance
Procurement including e-commerce
ISM
Crewing

Question 4

Are the on board system(s) integrated with the office system(s)?
By which means is the information carried ship/shore?

Question 5

Is the office management system directly integrated with any other system, e.g. the accounting system?
If so, from which supplier and how is the integration performed?

Question 6

Is your company using any technical condition monitoring system or equipment on board the vessels, such as vibration monitoring etc?
If so, from which supplier and onboard how many ships?
If not, which are the obstacles?

Question 7

Is the technical condition monitoring system(s) integrated with the on board maintenance management system?
If so, on board how many ships?
How is the condition monitoring data analysed, on board, by the technical department or by third party?

Question 8

By which classification society (-ies) are the majority of the vessels your company´s fleet classed.
By which machinery maintenance class arrangement is the majority of the vessels your company´s fleet operated, e.g. Planned Maintenance System?

Question 9

By which major maintenance strategy or technique is the vessels in your company´s fleet maintained; e.g. corrective, preventive, by condition or any other strategy such as RCM, Reliability Centred Maintenance?
Is there in your company a strategy to implement more condition monitoring techniques?

Question 10

Are there in your company any plans for implementing class surveys according CM class?
If yes, what benefits have you experienced or are expected to gain?
If not, which are the obstacles?

Survey results

Survey
Maritime Management Systems

Owner/Manager	Vessels	Type	Q1 Int. MMS Syst/Suppl	Q2 Integrated functionality M	P	E-com	ISM	Crew	Q3 System/Supplier of separate system M	P	E-com	ISM	Crew	Q4 Ship/ shore	Carrier	Q5 Other integr.	Q6 CM equip.	Occ.	Obst.	Q7 CM int.	Q8 Class soc.	Survey method	Q9 Maintenance strategy	CM strat.	Q10 CM class	Benefits	Obstacles
No. 1	12	10 Bulk / 1 RoRo / 1 Special	No	N/A	N/A	N/A	N/A	N/A	5	Prop.	No	Prop.	Prop.	Yes	SatCom	No	No	N/A	Cost	N/A	GL	Renewal	Prev. RT/Exp.	No	N/A	N/A	N/A
No. 2	30	21 RoRo / 2 Bulk / 7 Special	4	M	P	No	No	No	N/A	N/A	6	7	10	Yes	VSAT	A1	No	N/A	Old sh.	N/A	LR	PMS	Prev. RT	Yes	Yes	Reduced cost	Not feasible on old ships
No. 3	30	Tank	1	M	P	No	ISM	No	N/A	N/A	No	N/A	Prop.	Yes	SatB	A2	(No)	Few	Cost	N/A	DNV	Renewal	Prev./Proact.	No	No	Early warning	Costs/Data evaluation
No. 4	16	13 Pax/RoPax / 3 RoRo	4	M	P	No	(ISM)	No	N/A	N/A	No	7	11	Yes	VSAT	No	(No)	Few	Eval.	N/A	LR	PMS	Prev. RT/Exp.	No	No	Ext. intervals	Data analysis/Costs
No. 5	18	Tank	2*	M	P	No	No	No	N/A	N/A	No	Prop.*	Prop.*	Yes	VSAT	No	(No)	Few	Cost	N/A	DNV	PMS	Prev. RT/CB	No	No	Lower costs	No extended intervals
No. 6	11	8 Bulk / 3 Tank	Proprietary	M	P	No	ISM	No	N/A	N/A	No	N/A	12	Yes	SatB	Prop.	No	N/A	Neces.	N/A	LR	Renewal	Prev. RT/Exp.	No	No	Less inspec.	Training/Data evaluation
No. 7	10	Tank	2	M	P	No	No	No	N/A	N/A	No	Prop.*	11*	Yes	SatB/VSAT	No	(No)	Few	Op.	N/A	BV	Renewal	Prev. RT/Exp.	No	No	Commercial	Workload in office
No. 8	7	5 Pax/RoPax / 2 RoRo	3	M	P	No	No	No	N/A	N/A	No	8	11	Yes	VSAT	A3	(No)	Few	No b.	N/A	LR	CSM	Prev. RT	No	No	N/A	N/A
No. 9	33	RoRo	3	M	P	No	ISM	No	N/A	N/A	No	N/A	11	Yes	VSAT	A3	No	N/A	Equip.	N/A	LR	PMS	Prev. RT/Crit.	No	No	N/A	Surveys still were needed
No. 10	10	Tank	4	M	P	No	No	No	N/A	N/A	No	9*	Prop.	Yes	VSAT	No	No	N/A	Cost	N/A	DNV	PMS	Prev. RT/Exp.	No	No	Trend analysis	Costs/Equipm. sensitivity

	10 Swedish Owners/Managers		
	w. Technical-, Crew-, and Safety		
	management for	**177**	**Vessels**
	The Owners/Manangers are active in:		
	(some in more than one segment)		
5	Own./Man. with number of vessels	71	Tank
2	Own./Man. with number of vessels	18	Pax/RoPax
4	Own./Man. with number of vessels	60	RoRo
3	Own./Man. with number of vessels	20	Bulk
2	Own./Man. with number of vessels	8	Special service
	10 Swedish Owners/Managers		
	w. Technical-, Crew-, and Safety		
	management for	**177**	**Vessels**
	These 10 Owners/Managers		
	commercially control about	**300**	**Vessels**
	Maintenance Systems		
	Supplier 1	30	
	Supplier 2	28	
	Supplier 3	40	
	Supplier 4	56	
	Integrated systems	154	Vessels
	Supplier 5	12	
	Propietary	11	
	Total	**177**	**Vessels**

Abbreviations headlines

Int. MMS	Integrated Maritime Management Systems
Syst/Suppl	System/Supplier
M	Maintenance
P	Procurement
E-com	E-commerce
Other	
integr.	Other integration
CM	Condition Monitoring
equip.	equipment
int.	integration
strat.	future strategy
Class	Classification
soc.	society
Occ.	Occations/ships
Obst.	Obstacles

Systems/Suppliers

1	Int. MMS
2	Int. MMS
3	Int. MMS
4	Int. MMS
5	Maintenance
6	E-commerce
7	ISM
8	ISM
9	ISM
10	Crew
11	Crew
12	Crew
A1	Accounting 1
A2	Accounting 2
A3	Accounting 3
Prop.	Proprietary
*	System restructuring

Abbreviations other

N/A	Not applicable
Old sh.	Hard to implement on old ships
Eval.	Common data evaluation/Not properly adapted CM equipment
Neces.	Necessity/Cost/Lacking on-line communication
Op.	Overall operational costs incl. office time and personnel costs
No b.	No benefits, old problems solved/Quite new ships
Equip.	The CM equipment was not suitable for on board environment
Prev. RT/Exp.	Preventive RunTime based/By experience
Prev. RT	Preventive RunTime based
Prev./Proact.	Preventive/Proactive
Prev. RT/CB	Preventive RunTime based/By experience/Some condition monitoring
Prev. RT/Crit.	Preventive RunTime based/Criticality is introduced
Ext. intervals	No maintenance is carried out in vain/Intervals can be extended
No extend. intervals	Conservative thinking/CM can not grant extended intervals to 5 years on ME's anyhow

Classification societies

ABS	American Bureau of Shipping
BV	Bureau Veritas
DNV	Det Norske Veritas
GL	Germanischer Lloyd
LR	Lloyds Register
NKK	Nippon Kaiji Kyokai

Machinery survey methods

Renewal	Traditional 5 years
CSM	Continuous Survey Machinery
PMS	Planned Maintenance System
CM	Condition Monitoring