Storing maintenance and incident records: is there space for improvement?

A. L. Michala, I. Lazakis & K. Dikis
University of Strathclyde, Glasgow, U.K

ABSTRACT: Maintenance, incident and accident records are necessary for shipping companies to comply with regulation. Additionally these records are often used in conjunction with or separately from the Planned Maintenance System (PMS) for asset management, maintenance planning and spares. Moreover, appropriate use of PMS with correctly applied monitoring can significantly reduce accidents. Reduction of accidents is of paramount importance for safety of crew and passengers as well as protection of the environment and company reputation. This paper is based on a case study performed using the incident/accident records of a shipping company. The existing record keeping system was reviewed as part of the case study. Findings of the review included duplication of information, manual handing of the records for reporting purposes and lack of automation. Moreover, it was identified that information was not well correlated between the available company systems and departments, leaving room for improvement. Based on the results of the case study a gradual system of possible improvements was developed. The proposed system is presented through this paper. Initially the approach provides more automation and eliminates duplication. Benefits include less manual handling, automated and standardised plotting and reports and elimination of human error. The second stage includes the integration of the record keeping system with the PMS and records of Safety and Environment departments. Finally, the proposed system suggests the incorporation of Continuous Based Monitoring in order to optimise maintenance management and reduce incidents/accidents, increase fleet profitability and assist in meeting the business KPIs.

KEYWORDS: Incident record system; Accident record system; Planned Maintenance System; Continuous Based Maintenance

1 INTRODUCTION

In order to comply with the International Safety and Management (ISM) code of the IMO international regulatory framework (IMO, 1993), it is mandatory for a company to have a Planned Maintenance System (PMS) as well as maintain incident and accident records (IACS, 2014). It depends on the company operating the vessels and its policy, to identify which systems and methods are used to meet the obligatory requirements and to determine if these are linked or maintained separately.

Usually the PMS is used for asset management, maintenance planning and spares. Additionally, other record keeping systems are usually paper based and others are electronically recorded. Furthermore, in some cases independent vessels maintain independent records and no company wide system exists for the full fleet. Companies ofter rely on minimum requirements and do not use PMS systems to the full extend of their capabilities (DNV GL, 2014). Further utilising PMS systems linked with Condition Monitoring (CM) is an even more rare occurance, coresponding to approximatelly 2% of the global fleet (Shorten, 2012).

However, appropriate use of PMS with correctly applied monitoring can significantly reduce accidents (Logan, 2015). Reduction of accidents is of paramount importance for safety of crew and passengers as well as protection of the environment and company reputation which are some of the most important Key Performance Indicators (KPIs) in the shipping industry (MARINTEK, 2010). Hours Lost and Number of Incidents/Accidents were the core KPIs in this case.

Furthermore, with the increased regulation regarding environmental protection and reduction of emissions in the shipping industry, good maintenance condition of vessels is becoming more important than ever (ECSA, 2013, MEPC, 2011).

This paper will present a method of updating an existing PMS and Maintenance Incident/Accident

record keeping systems through a process that is focused on gradual improvement while respecting the existing company structures. Section 2 will present the methodology and section 3 the review of an existing incident/accident record keeping system of a shipping company with the intention of providing suggestions for improvement. Section 4 will present the application of the methodology on this system as a case study. Finally section 5 will conclude on the findings of the case study.

2 METHODOLOGY

Regardless of the existing record keeping system, a variety of data needs to be collected either manually or automatically to meet the regulatory requirements. Table 1 presents the parameters recorded as input of a typical incident/accident record keeping system. The method of storing and maintaining the data depends on the record keeping system which the company utilises. This system can be based on hard or soft copies of documents, on a database or other format.

Table 1. Record keeping system input.

Parameter
Date and time of accident/incident
Level of accident/incident (deficiency, breakdown etc.)
Affected vessel
Affected system, sub-system or component
Type of accident/incident (e.g. mechanical, electrical etc.)
Description
Operating hours lost (vessel out of service)
Corrective action taken
Controllable or Non-controllable type of event
Responsible technical staff member

The record keeping system output is dependent upon the requirements of the company. Predominantly it consists of graphs or plots, as well as tables based on the collected input data. Each company tailors the output of the record keeping system according to their report and management requirements.

For the improvement of a record keeping system it is important to maintain the same input information. In that respect the data recorded for each incident/accident should remain the same. Similarly for the company it is important to maintain the same output. In that respect the graphs and plots as well as the data structures required for reports should remain the same. The methodology is thus focused on improving the system without altering the input or output.

As presented in Figure 1 the proposed methodology can be divided in three distinct stages. The first stage is targeting the improvement of automation and reduction of manual data handling. The second stage is targeting the integration of more company systems to improve data visibility and data processing potential. Finally, the third stage is suggesting introduction of more sophisticated data collection to remove manual input data recording and provide the ability of prognostic and diagnostic maintenance.

Figure 1. Three stage improvement methodology.

For each of these stages to be successfully implemented and to incorporate the particular needs of the company an iterative process is followed (Fig. 2). Initially a review of the existing system must be performed irrespectively of the stage. Based on the outcomes of the review a set of particular improvement suggestions must be made to meet the goals of the particular stage. However, the suggestions must be presented to the company's technical personnel and crew so that they are consulted and feedback is received. Within this iterative process the most beneficial set of improvement suggestions can be identified.

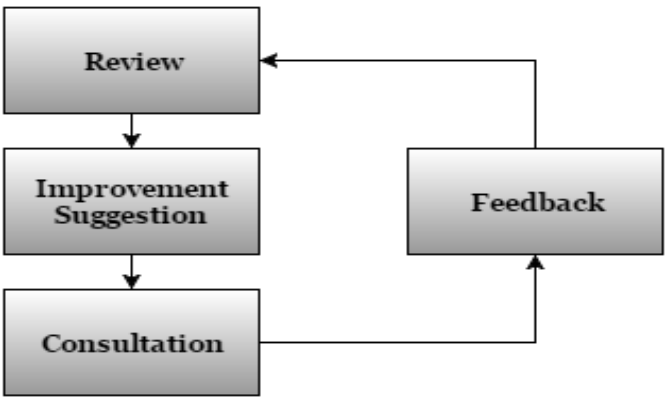

Figure 2. Itterative process for each stage.

This method allows the company to incorporate updates and changes without disturbing the current practices. As such this method can improve the record keeping system without causing inconvenience to the staff members involved in the accident/incident record maintenance process or the crew onboard the company's vessels.

3 EXISTING RECORDING SYSTEM

As the first stage of the methodology, the existing records system was reviewed. The input for the system was recorded manually and all the data presented in Table 1 was collected. The initial system was based on an extended system of excel files. The main accident/incident record keeping excel file was also requesting information from other excel files maintenance separately.

Furthermore, the main file included a number of spreadsheets that presented tables of subset of accidents or incidents. The data had to be manually introduced to each table and the user was responsible for assigning the correct data to the correct subset.

Moreover in many occasions the same data was manually re-introduced in several different spreadsheets. Graphs were produced and updated also manually making the spreadsheet difficult to read. Finally, a set of tables were created to assist in plotting leading to data being duplicated in several locations.

This section presents the review findings and demonstrates the possible shortcomings of such a system.

3.1 *Duplication of information*

One of the earlier findings was the fact that information was duplicated as it was recorded in several excel worksheets even in the same excel file. An example is demonstrated in Figure 3 where three worksheets contain the exact same information presented in sligtly different formats. Moreover, each worksheet included some information about a single incident or accident while another sheet recorded other types of information for the same incident/accident. Also plots and graphs were displayed on the same sheet and different sheets included different graphs displaying the same information in a variety of ways.

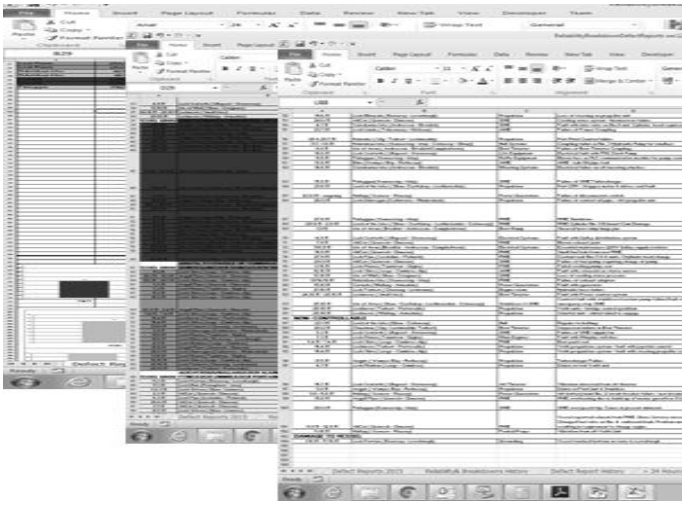

Figure 3. Multiple excel worksheets recording the same information.

Additionally, information was also cross-referenced from other excel files that also recorded the same data possibly in sligtly different format.

In that respect, information was not well correlated between the available company systems and departments. Several different files recorded information regarding incednts/accidents. Some of these resulted from the same accident/incident being recorded several times as the information was transferred from paper report form to electronic record.

Further more, the information from the incient/accident record was not well corelated with the information on the PMS system for the corrdination of spare part ordering.

3.2 *Lack of automation*

Additionally, the record keeping system involved manually handling information. This was present in several layers. Initally information was manually transferred from the paper forms completed by the engineers or fleet managers into the excel document. Then if any information needed to be copied to other worksheets it was often reinserted manually.

Additionally sums and averages were also inserted instead of calculated in excel. As a result the flexibility of the method was not considering the full potential of the existing system. Also the manual handling resulted in an increased effort and complexity and thus higher risk of error.

Due to the lack of automation and duplication of information it was easy for errors to manifest. This is due to the human factor involved in many of the record keeping processes. As demonstrated in literature human factors can affect the outcome of maintenance and relevant records (Dhillon, 1986, Dhillon & Liu, 2006).

Additionally the system was not able to produce automated reports to engineers, fleet managers and other stakeholders. This resulted in reports being produced manually, oftern containing information that was not relevant to the receipient of the report. Hence, reports were not often used to their full potential in causing the best potential string of actions to be taken to the benefit of the company, ship or crew onboard the vessel.

3.3 *Data from multiple sources*

Finally, it was identified that data of the same type was recorded in other excel files. Incident and accident records were not only reported in one excel file but rather in several excel files which in some cases comunicated. In that respect, records from another excel file were utilised in the studied excel file.

This leads to several issues. For example, is this cross-reference managed appropriately? Is the refered file only updated together with the file referencing? Who is coordinating the updates to ensure all files present the correct information? As a result the unecessary complexity of this system leaves a lot of room for human error and mis-representation of data.

3.4 *Output of initial system*

As required by the methodology the initial system's output was also reviewed. Table 2 below presents a list of all the graphs required by the company. Most

of the report requirements were focused on operating hours lost as a result of accidents or incidents in a monthly or annual basis. Also the number of accident or incidents was important for the company as it affected the Condition of Class, company profitability and maintenance management processes. In that respect the business's Key Performance Indicators (KPIs) were Hours Lost and Number of Incidents/Defects.

Table 2. Record keeping system output.

Parameter	Type
Number or incidents	Graph per month
Number or incidents	Graph per vessel
Breakdown and Reliability report	Table per year/vessel
Breakdown	Graph per system
Breakdown	Graph per type
Number or defects	Graph per month
Number or defects	Graph per vessel
Defect report	Table per year/vessel
Controllable against Non-controllable	Graph per month
Hours lost	Graph per month
Hours lost	Graph per vessel

4 CASE STUDY

According to the findings of the shipping company's system review the presented method of introducing gradual improvements to the record keeping system was applied.

4.1 *First stage*

The first stage is focused on improving the excel worksheet used withouth altering the format of the plots or tables used. During this stage the data gathering process is not altered. Data is collected by crew in the same manner as in the initial company approach.

The purpose is to provide more automation and eliminate duplication. Benefits of using the proposed excel include reduced manual handling of records, automated and standardised plotting and as well as the ability to generate standardised reports. At this stage the company can benefit from a more accurate record keeping system in being able to produce more accurate forecasts for maintenance tasks, part ordering and stock availability. Moreover, standardised reports can benefit staff and crew as the identification of maintenance needs for each vessel becomes easier.

Overall the most significant benefit is the elimination of human factor and resulting errors. This approach was developed by separating the excel in two worksheets.

4.1.1 *Input worksheet*

The first worksheet is the point of entry of new information and is presented in Figure 4. The purpose of this input worksheet is to create one single area for adding new records along with all the required information. To that end, all of the various types of information relevant to one single accident/incident are recorded in one line of the input sheet. This avoids duplication of information and human errors resulting from coping information or recording different information about the same record in different sheets.

It must be highlighted that the columns used for this table are exactly the same as those used in the original excel. However, in the original excel they were scattered in various worksheets while now they are collectively in one table.

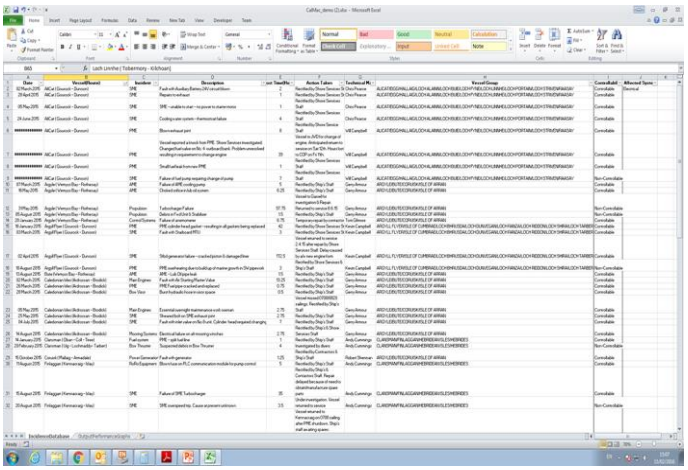

Figure 4. Input worksheet containing a single table.

The input worksheet also allowed for shorting the information and filtering based on any number of preferred parameters. This was achieved through the first line of the worksheet that included the titles of each column. In that respect the user would still be able to present information in a table format selectively. Thus, all the different worksheets existing in the old record keeping file could be generated in a simpler way. Information could then be printed based on the selection of preference for each member of staff or crew based on their needs.

4.1.2 *Output worksheet*

The output worksheet is the point of access to plots and graphs. All the desired plots and graphs that previously existed in the initial record keeping excel are available in this worksheet and accessible through drop down menus. All the graphs are now grouped in one worksheet. There are two drop down menus. Each of them corresponds to one of the business's KPIs.

As the Hours Lost was one of the most important KPIs for the particular business several plots of this information were available. These are grouping the hours lost as a result of an accident/incident by month, fleet or vessel so that different reports can be generated and addressed to different staff members according to their needs and requirements. An example of the selections available is presented in Fig-

ure 5. The other KPI was the number of accidents/incidents. The relevant drop down menu again provided graphs presenting information per month, year, fleet or vessel. Also other options were available based on the requirements of the old excel.

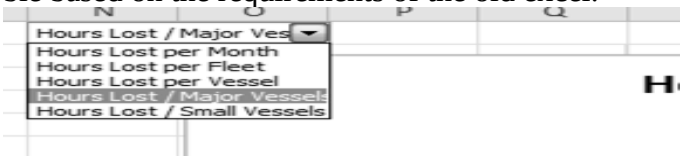

Figure 5. Drop down menu for the selection of graphs in the Hours Lost category.

The output worksheet is presented in Figure 6. As demonstrated the two selections are available corresponding to the two KPIs. The user can adjust each plotting area and flexibly alter between information presented.

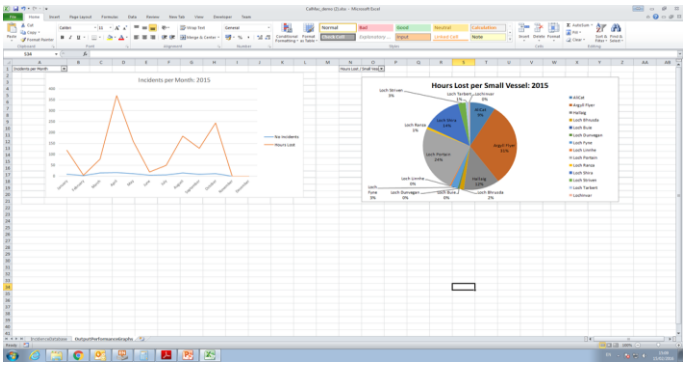

Figure 6. Output worksheet with two graphs corresponding to the two KPIs of the business.

Figure 7 presents a different set of selections from the drop down menus on the same excel worksheet. The output worksheets provide the user with a long variety of displayed information for comparison, cross-referencing and reporting.

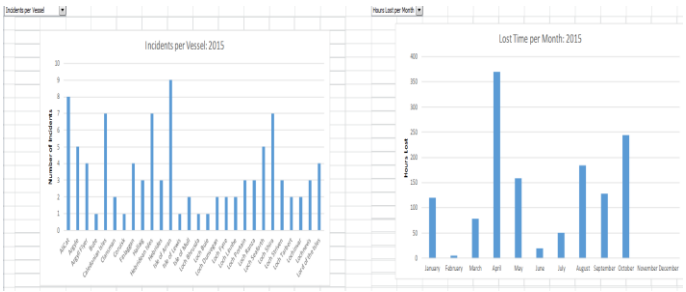

Figure 7. Selecting different options from the drop down menu presents different pre-requisite graphs for the two KPIs (i.e. Number of Incidents, Hours Lost).

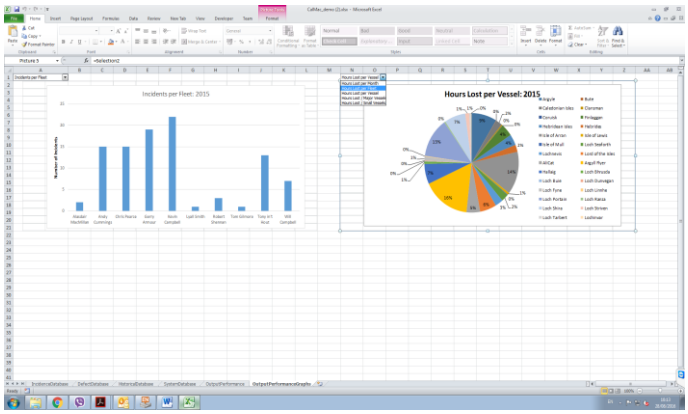

Figure 8. Automated update of graphs on selection.

By selecting an option from one of the drop down menus the relevant plotting area is automatically updated displaying the desired graph. Figure 8 presents another example of selected graphs for the same plotting area as Figure 7. As such no manual intervention is allowed in the information collected for this graph or the way the graph is presented. In that respect the human error is eliminated and the graphs are standardised.

Another benefit of the presented excel approach is that it requires almost no training. As such anyone can generate the desired data presentations with minimal effort. All that is required is consistency in the input worksheet

4.2 *Second stage*

The proposed methodology suggests the PMS and records of Safety, Quality and Environment departments integration as the second stage. In that respect, the full record keeping system is proposed to be developed in Java Programming Language as a standalone application. The proposition is that the input and output worksheets demonstrated in the first stage are maintained in the new software. In that respect the input area presents a table of records that can be filtered and shorted. Also it provides a space for the introduction of new records in the format of a table row. Similarly the output tab of the developed software will present the exact same graphs using the drop down menus corresponding exactly to the first stage.

Through this approach consistency is maintained and no additional training is required. Moreover, the software can directly use all the records from the excel sheet of the first stage and hence allowing backward compatibility. If new records are added to the first stage excel it is a simple task to upload them to the software.

Moreover, as the custom-made software can be developed with additional features the potential is limitless. As such, the flexibility of the developed software is also a benefit to the company. In that respect automated reports can be integrated which are different for Superintendent, Onboard Crew, Fleet

Manager etc. and are directly emailed or sent to their phones.

Another benefit of this stage is that automated data input/output can be facilitated between the developed record keeping software and the PMS system or the systems used by the Safety and Environment departments. In that respect better spare part management and better asset management can be facilitated automatically. No staff training or manual duplication of information to updated other systems is required.

Finally, new features can be added gradually to the software in order to grow along with the business. For example this stage can be ideally utilised for connection with a Continuous Based Monitoring system as proposed in the next and final stage proposed by this method of improvement of the record keeping system. This stage is further discussed in the following paragraphs.

4.3 *Third stage*

The third and final stage of the proposed system suggests the incorporation of Continuous Based Monitoring (CBM). This can be used in order to optimise maintenance management and reduce incidents/accidents, increase fleet profitability and assist in meeting the business KPIs.

Reduction of unexpected accidents/incidents through CBM is well documented in the literature in the shipping industry (MoD, 2006a, 2006b, Greene, 2006, Jardine et al., 2006, DoD, 2008, Jiang & Yan, 2008, Hashemian & Bean, 2011, DNV GL, 2014, Kara et al., 2015, Lazakis et al., 2016, Michala et al., 2016, Lazakis et al., 2017). CBM can lead to optimised and efficient maintenance planning and asset management. Additionally, it can provide the basis of optimised spare part ordering and optimised cost of maintenance (SKF, 2008, DNV GL, 2014). As such not only the Number of Incidents/Accidents can be reduced and the Hours Lost minimised but other KPIs can also be improved through the appropriate application of CBM on the company's fleet.

5 CONCLUSIONS

This paper has presented a method for evaluating the existing accident/incident record keeping system of a shipping company. Through maintaining consistency in the input data and output produced and following the proposed three-stage iterative process, the system can be improved. It was demonstrated through a case study based on a shipping company's record keeping system that there is room for improvement of the maintenance strategies used and incident/accident records. Through the proposed method of a gradual integration of improved records and improved maintenance strategy can be implemented. The method proposed has taken into account not only the busness KPIs but also the learning curve for the employees including training. Finally, the proposed method sustains compatibility with the old system and reporting system. Via implementation of the porposed method of improvement, the busness can optimise maintenance management and reduce incidents/accidents, increase fleet profitability and optimise the business KPIs without affecting data confidentiality, security or regulatory requirements.

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